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RABBITO OR SURFACE TAINT IN BUTTER.

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For several years a butter defect has been present spasmodically in West Aus-

ERRATUM.

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"Hatch Your Chickens at the Right Time."

P. 17, para. 6, line 2: It is obvious that "4/- per bird" should read "5/- per bird," but a line was omitted which was intended to express that in order to give a greater strength to the discussion, a basis of only 4/- per bird would be taken.

"The Occurrence of Solonetz (Structural Alkali) Soils in Western Australia."

P. 99, para. 6, line 11: "Teakle (1937b)" should read "Teakle and Southern (1937)."

P. 109: Between lines 6 and 7 insert "Teakle and Southern."

An offensive aroma on the surface usually is the first indication of the trouble. A peculiar sweetish flavour somewhat resembling that of condensed milk is sometimes noticed. The aroma quickly accentuates. A freshly cut surface may not show the aroma but it usually develops if held for a short period, even overnight. After holding the butter at the higher temperatures for some time the odor seems to disappear, but by this time the flavour of the butter is such as to render it very unpalatable.

OCCURRENCE.

The first reference to surface taint butter as such was in Western Canada in 1919. Since then it has been reported from several other parts of the Dominion. It has been described as Limburger flavour in the United States, as a putrid flav-

our in Denmark, as a foetid odor in New Zealand and as decomposed odor and rabbito in Australia.

It occurs in butter made from the choicest creams as well as in those made from inferior creams, in butter manufactured in well kept factories as well as in that made in those not so well kept. It sometimes occurs in one churning and is absent from a number of succeeding ones. It may occur in butter made in one churn and not in another for a period and then without apparent reason or change in procedure the trouble will appear in the butter made in the second churn more frequently than in that from the first. Pasteurisation of cream has been demonstrated repeatedly to have been carried out efficiently prior to its appearance. Summer conditions appear more favourable to its appearance although it has been encountered at all seasons.

HISTORICAL.

This defect was for a long period attributed to the working of the organism *Bacillus fluorescens liquifaciens*. In 1899 *Gilruth* in New Zealand drew attention to the possibility of butter which had been of first-class quality before export being "uneatable" soon after its arrival in London. He demonstrated the production of a "foetid odor" in butter by inoculating into samples B fluorescens liquifaciens which he had isolated from water. The odor appeared in butter in 36 hours when held at 65 deg. F.; in 3 days when held in a cold room at about 45 deg. F.; while further samples held at 32 deg. F. for a month did not show the defect but then developed the odor in 2 days when kept at a temperature more favourable for bacterial growth.

In 1900 an outbreak of "putrid" butter in Iowa was investigated by *Eccles*. This butter was quite unfit for table use, having a strong disagreeable taste and a "putrid" smell. Small samples of this butter inoculated into quantities of sterile milk were responsible for the production of a similar smell in the milk but much stronger. Two organisms capable of causing the "putrid" condition in butter were isolated, the less objectionable one being *B. fluorescens liquifaciens*. The second organism was not definitely identified. The creamery troubled with this defect was advised to overhaul the whole of its plant and methods, to reject any raw material giving any suggestion of the "putrid" condition, to sterilize the whole of the plant, to pasteurise the skim-milk before returning it to the suppliers, and to use a large quantity of butter starter. During this period an extended dry spell had been experienced and dust storms were comparatively frequent. At about the same time as the suggestions were made the drought broke, bringing heavy rains. The trouble disappeared and there is little evidence to show whether any or all of the factors mentioned were responsible for the trouble.

Marker apparently was the first to suggest the term surface flavour for this defect as it first becomes noticeable at the surface of the butter. He suggested that the conditions in butter which were suitable for the development of surface taint were bound up with the neutralisation of the cream.

Sadler and Vollum in their investigations in Canada with surface taint butter were able to note the conditions at the plants producing the butter. It was obvious that contamination was possible following pasteurisation. The water supplies for washing the butter were not satisfactory, while it was also shown that micro organisms of the Escherichia-Aerobacter type were reaching the butter during packing. Organisms isolated during the investigation were used in experimental churnings by Sadler and Cameron. A spore forming milk digesting micro organism in combination with one of the Escherichia-Aerobacter type caused a condi-

tion resembling surface taint when used in cream neutralised to between .10 and .21 per cent. but failed to do so when the cream was churned with a higher acidity (above .3 per cent.).

Cordes and Macy reported that surface taint butter contained large numbers of bacteria and yeasts. Macy inclined to the view that a large coccus form in association with yeasts were responsible for the trouble.

Hood and White of Canada studied surface taint butter and reported that during the years 1926-7 all butters analysed contained large numbers of bacteria capable of decomposing curd, while the total bacteria and yeast content was abnormally high. Routine examinations of butter from creameries affected with the trouble usually showed high counts but several low counts were also made. They concluded that this indicated inefficient sanitary control. They also showed that many samples of butter from unpasteurised cream contained fewer bacteria than surface taint butter.

Trials were made by inoculating various organisms isolated from well water into pasteurised neutralised cream and then churning the cream. In some cases the defect was apparent in as short a period as two days. A number of liquefying organisms were shown to be present in the water supplies of the creameries visited.

Shutt concluded that impure water supplies were responsible for the occurrence of surface taint. He indicated that city creameries were free of the trouble, having pure water supplies, and that it was a common defect in butter from rural creameries, particularly following prolonged periods of wet weather. The principal organism present in contaminated water was *Ps fluorescens*, with many other putrefactive bacteria. He showed that surface taint could be produced by inoculating *Ps fluorescens* into sterile butter and holding it at 25deg. C. for 28 days.

The following suggestions were made for controlling the defect:—

1. Substitution of pure water for contaminated water for butter making. In rural areas this meant the sinking of new deep wells.
2. Where municipal water supplies were involved or where contaminated water from other sources had to be used it was suggested that the water be heated to a temperature of 190deg. F. for 10 minutes and cooled before washing the butter.
3. Cream be neutralised to .35 per cent. acid instead of the .25 per cent. acid. This applied to cases where it was impossible to safeguard the quality of the water as indicated in 1 and 2 above.

Rumment showed that the *B. fluorescens liquifaciens* will grow freely in sweet butter (p.h. 6.8). He also stated that the free fatty acids formed by its attacking the fat have a destructive effect on the organism.

Brown, of New South Wales, reported his investigations of a defect of butter in that State referred to as a "disagreeable aroma." There seems little doubt that this is a similar defect to surface taint. Evidence was claimed to show that insanitary conditions in factories such as recontaminating foci in churns, workers and other wooden utensils, and the bacterial action in the butter brought about by this contamination was at least partly responsible for the aroma. It was concluded that the alteration in curdy material causing the aroma commenced before the butter was churned, in the putrescent curdy material which exudes from the glands of storage vats and churns, and from the crevices in churns and workers, etc. This curdy material becomes thoroughly incorporated in the butter during manufacture and there was considered to continue its breakdown, by the action of enzymes and bacterial products, producing the characteristic odor of decomposition. This

view was supported by the fact that in the examination of many samples of the bad butter putrefactive bacteria were not present in sufficient numbers to cause trouble. It was reported that when the wooden surfaces with which the cream and butter come in contact were thoroughly cleansed the defect disappeared. Particular attention was paid to any fat-saturated surfaces and in some cases it was necessary to replace articles of equipment which had been allowed to get into this condition.

The mode of occurrence of the defect was consistent with the conditions as occurred elsewhere; *e.g.*, its occurrence was spasmodic both in relation to time and district. It occurred in one churning and not in another even from the same vat.

Derby and Hammer undertook an investigation with the object of studying (a) the cause of surface taint, (b) the factors influencing its development. They stated that surface taint could not be developed by inoculating a normal product either salted or unsalted with surface taint butter, but could be developed by inoculating the defective butter into pasteurised cream and churning the cream. From 2-4 days was necessary to develop the taint.

In most cases surface taint butter was unsalted or had a low salt content and was held at temperatures very favourable to bacterial growth.

It was also ascertained that the predominating organisms obtained on plates prepared from affected butter would not produce surface taint when inoculated into pasteurised cream and the cream churned.

They were successful in isolating an organism which they believed was an undescribed species, which was capable of producing surface taint when inoculated cream was churned. They called this *Achromobacter putrifaciens*. This organism was isolated from many samples but could not be regularly secured from all. Other organisms capable of producing the taint were also secured. These organisms were always present in small numbers.

The organisms which would produce surface taint were greatly restrained by the use of medium salt percentages and/or butter culture in the making of butter.

In trials carried out with *Ps fluorescens* rancidity regularly and rapidly developed.

The change in the butter did not resemble surface taint after one day.

Comment was made on the variations of surface taint in the various samples forwarded for examination.

In South Australia *Lock* stated that rabbito would develop during warm weather, in flush periods when insufficient time is allowed for cleaning, after heavy showers late in the season, when lumpy cream was not thoroughly mixed prior to pasteurising, and in badly worked butters. Where the water supply was exceptionally bad, it would develop at any time other than in very cold weather. The degree of rabbito was said to vary with the amount of contamination, the curd content, the temperature and the method of working. Prevention was suggested by the control of water, attention to correct acidities and moderate but efficient temperatures of pasteurisation, the heat treatment of all equipment immediately before the cream comes in contact with the surfaces thereof, the thorough cleansing of churns and the thorough working of the butter. *Pseudomonas fluorescens* was referred to as an organism frequently found in water and considered a possible cause of rabbito butter.

In Victoria, *Loftus Hills, Scharp and Searle* investigated the defect. They concluded that—

1. No particular district seemed to favour the defect.
2. The defect is essentially a summer one.
3. The bacterial counts of rabbito butters are extremely high.

4. The defect requires time to develop, usually 2-4 days after manufacture being required to show its characteristics.
5. Rabbito butter worked into (1) unsalted sterile butter, (2) sterile butter 1 per cent. salt, (3) sterile butter 2 per cent. salt, caused the development of its characteristics in the inoculated samples.
6. High salt, *e.g.* 3 per cent. and high acid in the cream, over .2 per cent., greatly slowed up the change.
7. A culture of micro-organisms isolated from rabbito butter worked into sterile butter caused the typical development.
8. The bacteria were included in factory butter during manufacture due to ineffective methods of bacterial control, *i.e.* faulty pasteurisation and subsequent contamination.
9. Control consists of efficient pasteurisation and the minimum of recontamination after pasteurisation.
10. The origin of the organisms was not located, but churns were considered the most likely source. The instance of the defect disappearing when a contaminated churn was replaced with a new one was given.

A warning that other sources of infection such as the water supply storage tanks, cream vats, etc., could be causing the trouble was given.

A later report indicated that rabbito organisms had been isolated from factory water supplies, churns, raw cream and pasteurised cream. It was considered likely that the natural habitat was water. The organisms were shown to be similar to those isolated by Hammer and others in Iowa, U.S.A., from surface taint butter and to be capable of producing identical characteristics in inoculated butter. The possibility of poor texture in butter rendering it more prone to development of the defect was made, the comparatively less thorough distribution of the moisture droplets being suggested as the reason.

In Western Australia for several years there have been spasmodic outbreaks of deterioration which appeared akin to rabbito or surface taint. Our first record is the report of the then Dairy Expert, Mr. P. G. Hampshire, on his investigation into an outbreak of "stinking butter" in 1927. He pointed to inefficient grading, neutralisation and pasteurisation and to the quality of the wash water as being contributing factors. His reference to the quality of the butter wash water is interesting: "Samples taken at the tank and at the churn showed the presence of coliform bacteria which would develop trouble in the butter after manufacture and undo the work of efficient grading and pasteurisation, there being present in the water at the top of the tank 200 organisms per c.c. The water at the churn showed 2,000 organisms per c.c. with coliform organisms present."

The presence of many spore-forming bacteria in the butter was interpreted as indicating faulty grading, while a large number of coliform organisms in the vat after pasteurisation was said to indicate faulty pasteurisation.

In 1931-2 Miss E. A. Newton, bacteriologist for the Westralian Farmers, Ltd., Pascomi, Perth, carried out a number of routine examinations of butter and rinse waters. Some very high counts were recorded both from butters and from the factory equipment. She referred to a spore-forming organism which occurred in the butter samples and in samples from various points in the plant. It was suggested that this organism was possibly responsible for the poor quality of the butter.

In 1934 another bad outbreak occurred at the same factory and after a careful checking of all plant and methods, bacteriological examination indicated undue contamination taking place on the cooler.

The details of this examination indicated efficient pasteurisation but heavy contamination occurring immediately after.

	Total Organisms. per c.c.	B. Coli.
Cream before pasteurising	Millions	Present in 1/10
,, after pasteurising	600	*Nil*
,, at one end of water cooler * ...	1,500	*Nil*
,, in holding vat	Uncountable	
Buttermilk	Uncountable	
Butter	88,000	

* Not from the mixed cream in the tray below the cooler.

Further investigation of this point led to the discovery of a hollow flange which was full of particularly offensive decomposed cream. When this was cleaned up the outbreak of stinking butter stopped.

RECENT INVESTIGATIONS.

In 1935 there was a recurrence of the same type of trouble. Following on a few churnings being reported as affected, hand churnings of cream taken from the pipe leading to the churns were carried out each morning for one month. One sample was held from each bulk churning. During this period three consignments were reported as bad. The three samples from these consignments held in the laboratory were also bad, while the samples churned in the metal hand churn from the same cream showed no defect. This indicated churn contamination and was confirmed by a test in the factory. It was noticed that the defect appeared regularly in butter made from one churn only. The churn was put out of commission for two weeks and during that period no defect was noticed in the butter. The churn was again put into commission and the first churning developed the trouble. As the barrel was old it was decided to replace it.

This was done and the trouble disappeared until early in 1936 when the defect was again observed, but on this occasion the source of the trouble was more difficult to locate. It would appear in butter made from one churn and not in that made in the other; then for no apparent reason the trouble would appear in buttter from the second churn and not from the first. No consistent evidence was available pointing to any one holding vat or any other part of the equipment.

Bacteriological surveys of the plant carried out at that time indicated that pasteurisation was regularly efficient but also that a certain amount of contamination was occurring after, and most of all in the churns. The table hereunder shows the results of two surveys made immediately before and after the plant had been closed down for a week for a thorough overhaul.

	Before Overhaul.		After Overhaul.	
	Total.	Coli/c.c.	Total.	Coli/c.c.
Main Water before use	60	—	30	—
,, in Tipping Vat	600	+	200	—
,, in Neutralising Vat	850	+	1,250	—
,, after Pasteurising	40	—	100	—
,, after Cooling	250	—	22	—
,, Entrance Vat	500	—		
,, from Vat 2 (next morning) ...	450	—	100	
,, from Vat 3 ,, ,, ...	500	—		
,, from Vat 2 to Churn 1 ...	400	—		
,, from Vat 3 to Churn 2 ...	1,750	—	80	—
,, from Churn 1	20,000	Uncountable	1,000	300
,, from Churn 2	45,000	150	1,000	20

Eventually it was noticed that it was the butter which was made from the last portion of cream left in a vat which most frequently developed the taint. This cream was as a matter of routine washed from the vat to the churn with a certain

amount of rinse water. This naturally focused attention on the purity of the water supply and although the number of organisms present at that time was not considered excessive it was decided to treat the water. This was effected by using certain chlorine preparations. For a time relief was again experienced and then on a further outbreak it was found that the chlorine treatment was not regularly effective. For a short time the use of boiled water was tried. However, the seasonal increase in cream supplies rendered the further use of a vat for the purpose of cooling this water impossible and reliance had to be again placed on the water steriliser which was believed not to be fully effective. A short while after the above it was suggested that the cause in other places of a butter defect similar to that under discussion had been shown to be due to casein digesting organisms. A number of isolations were made of organisms from agar plates with the addition of a small quantity of sterile dried buttermilk and experimental churnings with inoculated cream were carried out. The resulting butters, though showing high counts showed no similarity to the typical condition.

Spasmodic occurrences of the defect eventually brought the decision to put down a private bore. This was done and only a few churnings have since been affected. These being within a short period of the change over of the water supply, it appears reasonable to assume that the causative organisms if water borne would then still be present in the factory pipe lines and possibly in churns, etc. However, for 12 months now there has not been a recurrence at this factory.

Owing to the frequency with which the defect became noticeable over a period of years, considerable attention was given about this time to the possibility of locating the causative organism and the conditions under which it became operative. The work commenced with a detailed visual and bacteriological examination of the plant, but with no pertinent results. Samples of affected butter were obtained for examination. Counts made on these samples usually gave very high results, but occasionally a bad sample would show a lower count than good butter made in another churning from the same vat of cream. Counts made on gelatine were without exception higher than those made on agar. Isolations were made of a number of organisms from these plates and cultures were used for inoculating pasteurised cream before churning in a small hand churn. Among these was a spore-forming organism which occurred regularly in the affected butter. Churnings made with cream inoculated with these organisms and with various materials from around the factory which were considered as possible sources such as the curdy material from the roller glands in churns, dust from ceilings, contaminated water from various places, were generally unsuccessful. However, a variety of defects were produced, demonstrating the presence of undesirable organisms in the butter or around the factory. Attention was then given also to the possibility of locating the bacteria from the factory plant or from the wash water. Some failures were experienced through the cultures being short lived. This proved the case with one particular organism isolated regularly from the water supply and which in sterile butter plates gave an odour resembling surface taint. This culture was always short lived. This suggested the possibility of the causative organism not being persistent in the altered conditions brought about in the butter. Owing to the published references to the effects of *B. fluorescens liquifaciens* and of Hammer's bacteria particular attention was paid to the possible occurrence of these types and eventually organisms similar to the latter were isolated from two water supplies. There appears to be some variation in types in these organisms particularly in the speed of their gelatine liquefication. Experimental churnings with these cultures exhibited a similar condition to the typical defect. As a matter of routine hot bottle tests were made daily of the butter made in this factory and

on three occasions only did the characteristic aroma become noticeable. One of these churnings was reported bad by the retailers and on no other occasion were complaints received while these tests were being carried out.

Regular butter analyses for salt, fat, curd and moisture were also carried out during this period. These showed no significant results. Curd was frequently a little high, averaging 1.2 per cent. An alteration in churning methods with the use of break water brought the percentage to .8-.9 per cent. The butter showed on an average 1.5 per cent. salt and the cream at churning contained approximately .15 per cent. acid. Certain butters from another factory at this time showed salt percentages regularly as low as 1.2 per cent. and 1.3 per cent. Attention was drawn to the inhibiting effect of salt and curd as reported by Hammer, Loftus Hills and others, and it was suggested that the salt percentage be increased to 1.75 per cent. and that .2 per cent. acid be left in the cream at churning. This was a temporary measure to lessen the incidence of the trouble at the time. That no further trouble occurred following this instruction does not necessarily infer that the move was effective as other factors were operating. The season was changing from summer to autumn with its cooler temperatures and there was an increase in the quantity of butter being manufactured. Further, there had been an alteration in the water supply at the principal factory, which now was obtaining its supplies from a private bore.

The water supply at one factory from which the organism was isolated was known to be poor and that it was necessary to take some steps to improve it. Arrangements have been made to sink a private bore and the results will be awaited with interest, although it is several months since any trouble has been experienced there. In this factory also during a period when the defect was appearing, a very serious focus of contamination was discovered in a water pipe line where an accumulation of stale cream was available as a food reservoir for any harmful bacteria which might have been present in the cream or in the water.

In another factory, two churnings were found to be affected recently and although there had been reason to suspect insanitary conditions some weeks prior, surveys had shown the equipment to be in reasonable condition a few days before the outbreak. On investigation it was found that there was a strong possibility of the water supply being contaminated at that time. In this case water is drawn from a town scheme. The town reservoir tanks at one time were cleansed regularly every few weeks, but for some reason this cleansing was overlooked for about a year. It transpired that the delayed cleaning took place the day before the first case of bad butter was made. No further trouble has been experienced.

In one other factory an organism has been isolated from the wash water similar to that referred to earlier and there appears little doubt that it is the causative organism either alone or in combination with other organisms or certain conditions.

At this factory where consistent trouble was experienced for a fortnight, attention was given to the manufacture of the butter in order to be sure that moisture incorporation was thorough. This was done because of an incident in the manufacture of what resulted in the first case experienced at this factory. Owing to a breakdown in the wash water supply a churning was left standing at the grain stage for some time and eventually resulted in a greasy, fairly moist butter. This butter was considered unfit for sale in its then condition and it was decided to rework it by adding a few boxes at a time to succeeding churnings. This procedure was carried out and the butter from each of the churnings

so treated fell rapidly in quality. The incident was brought forcibly to memory when the sequence of bad reports was received. But when the bad reports continued after the original churning had been disposed of, other possibilities were considered. The possibility of the faulty texture contributing to the trouble was accepted and instructions were given to the buttermakers to be particularly careful in seeing that each churning was thoroughly worked. Later, in going through this factory's records it was seen that in approximately 70 per cent. of the cases, the butter had had only one working. That is, when the butter was worked dry and the first moisture test taken, it was found that no additional water was required to bring the quantity up to requirements. The butter was then removed from the churn with no further working (it being the busy season).

A further interesting point also arose from an examination of the records. In addition to the 70 per cent. rabbito butters among those receiving only one working, there was an additional 20 per cent. of these butters which were packed specially for the metropolitan retail trade and were to be cut by a special Benhill automatic machine. Butters going through this machine need thorough incorporation of moisture, otherwise appreciable loss occurs in the process of cutting. It appears reasonable to assume, and this assumption is supported by the manager of the factory, that this butter would receive special working as the buttermakers knew of its destination because of the type of box into which it was to be packed. In those cases where the moisture was low the second working apparently distributed the bulk of the water in much finer condition. After attention was given to thorough working no further trouble was experienced.

Some space has been devoted to an account of the defect in other countries and other parts of Australia in order to emphasise the point that the trouble is not unique to our State or, as has been suggested, to one factory. It is known that butter of this type has been manufactured at practically all factories in this State. The trouble of course becomes most evident when it appears in butter made from choice cream in factories which consistently make good-quality butter.

TENTATIVE CONCLUSIONS.

The conclusions from the information available are that:—

1. The defect is of bacterial origin.
2. The causative organism is probably water borne.
3. Foci of contamination are built up in the factory from initial contamination from the water. The most likely place for these foci is in the churns, between the staves in the worker glands, in the workers themselves, or in any other place where a lodgment of cream or other food material may occur.
4. Faulty manufacture probably assists in the development of the trouble. Thorough working safeguards quality.
5. High salt content and high acidity in the cream at churning apparently retards development of the fault.

While it must be realised that the whole story of this defect is not known, sufficient information is available to enable us to make suggestions for the control of the defect.

It is known that the heat resistance of the organisms responsible for the condition is not high and that ordinary pasteurising temperatures will destroy them. Therefore if pasteurisation is efficient there must be sources of contamination throughout the plant. It appears likely that the principal primary source

of the organisms is the water and so steps to purify the water supply are necessary. This can be effected by various types of steam and chemical sterilisers and bacterial filters. Where steam sterilisers are used, regular attention is necessary to make sure that they are working efficiently. Probably the most efficient system is the use of chlorine gas direct into the water supply.

There are many points in the various machines with which cream and butter come in contact which could be serious contaminating centres. Care is essential in order to be sure that satisfactory systems of cleaning and sterilising are employed. This appears to be particularly necessary in the churns, where prolonged heat treatment seems the most satisfactory method.

The percentage of salt used appears to have some bearing on the control of bacteria in butter and evidence is available to show a relationship with the development of surface taint. The majority of butters with this defect appear to have low salt content. In actual trials, Hammer showed that butter with 1.5 per cent. of salt and a low moisture content did not develop the condition. Loftus Hills showed development with 2 per cent. salt in sterile butter, but with 3 per cent. salt the condition was definitely retarded. It seems probable that some other factor was also operating in the cases cited, probably the number of lactic organisms present or the actual acidity of the butter.

Temperature is of course a controlling factor of bacterial development. Low temperatures may prevent deterioration in heavily contaminated samples, while higher temperatures would allow a rapid breakdown. In the retail trade, however, it is normal for butter at same stage to meet higher temperatures, and therefore it is particularly necessary to manufacture butter having only few organisms capable of causing change.

The texture of the butter or the degree of working appears to be an important factor in the development of bacterial troubles, and there have been indications that "rabbito" is related to the texture or the fineness of distribution of the water droplets. In measures suggested for the control of the defect therefore it is necessary to include attention to this aspect. The smaller the droplets of moisture in butter, the greater the number that will be sterile, and the smaller the amount of food material that will be available at the water fat junction, it being reasonable to assume that migration of organisms from one droplet to another does not take place.

In conclusion, the suggestions made may be summarised as under:—

1. Pasteurise efficiently.
2. Keep plant in a sanitary condition.
3. Purify the water supply.
4. Work the butter thoroughly so as to obtain a fine water incorporation.

If these are applied efficiently it should safeguard against any breakdown of this type.

ACKNOWLEDGMENT.

The writers desire to thank the South-West Co-operative Dairy Farmers Ltd. and particularly Messrs. L. M. Bentley and H. M. Lister for the facilities made available and the assistance given readily at all times in their endeavours to gain further light on this problem in Western Australia. To Mr. Scharp, formerly of the Victorian Department of Agriculture, their thanks are also extended for forwarding cultures of rabbito organisms isolated in Victoria, and to the Plant Pathologist, Mr. H. A. Pittman, and the Dairy Bacteriologist, Mr. H. Kretchmar, for discussion from time to time during the progress of the work.

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SOME FACTORS AFFECTING SEED POTATOES.

By E. T. MORGAN,
Officer in Charge, Potato Branch.

[*The following article is the text of an address broadcast through Station 6WF of the Australian Broadcasting Commission on Friday 25th February,* 1938.]

The opinion is held widely among potato growers that a variety of potato, if continually grown under the same soil and climatic conditions, will inevitably deteriorate, and that if the yield, quality and disease-resisting powers of the potato crop are to be maintained, it is necessary that new varieties which have been raised from true seed, should be introduced from time to time, or that a change of seed should be frequently made from different soil and climatic conditions. Many different opinions, however, are held regarding the ultimate cause or causes of this so-called deterioration and I want to discuss some of these in the light of the results of experimental work dealing with the subject which have been carried out in Scotland during recent years (*vide* Scottish *Journal of Agriculture,* No. I., Vol. VI.).

The experiments referred to were carried out for the purpose of obtaining information regarding the effect of—

(1) Continuously selecting large, medium or small sets.

(2) Continuously selecting seed from large plants and from small plants.

(3) Using seed obtained from a good crop and from a poor crop.

Large, Medium and Small Sets.

In the experiments referred to three varieties of potatoes, representative of well-marked types—Abundance, British Queen and Great Scot—were used. Three sizes of tubers of each variety were selected from the ordinary crop. The large tubers selected were twice the size of the medium, so that when these large tubers were cut in two with the medium size uncut, the sets were the same size and weight. On the other hand the small sets selected were half the size of the medium sets. All three were then planted under identically the same conditions and the same method of separation was practised in subsequent years; that is, every year the large sets were selected from the plants arising from the large sets, medium plants arising from medium sets and small from plants from small sets.

After a five-year period the averages worked out at—

Abundance.

Large sets, 16 tons 7 cwt. per acre; Medium 15 tons 6 cwt., and Small 15 tons.

British Queen.

Large 15 tons 18 cwt., Medium 16 tons 7 cwt., and Small 15 tons 7 cwt.

Great Scot.

Large 17 tons 3 cwt., Medium 17 tons 13 cwt., and Small 15 tons.

Regarding these figures it may be pointed out that the medium sets have in the main given rather the heaviest crop and that the lightest crop, on the other hand, has been got from the use of small sets. Generally it is found advantageous to

use good sized seed (2 to 3 ozs.) rather than small, because with the larger food store in the seed the plant gets a better start and the crop is almost invariably heavier. The important fact stands out that the relative yields from the three classes of sets were practically the same at the end of the five-year experimental period as they were at the beginning. If selection in this way has any effect at all, it would naturally be cumulative, but there has been no falling away in yield from the use of the small sets, nor any addition to the yield from the use of the medium and large cut sets. That is to say, the continued selection of the small sets has not led to any deterioration; neither has the continued selection of the large sets led to any improvement.

It was further observed in each year when the crop was harvested that the proportion of small tubers from the small sets was not any greater than from the medium or large sets. Indeed, it was noted that from the large cut and from the small sets there was rather a larger proportion of what may be termed show specimens than from the medium sets. In the case of the small sets, in one or two seasons there was considerable difficulty in getting a sufficient number of small tubers to continue the trials.

One point of interest which emerged in these trials, but which has no direct bearing on the subject under discussion, was that the crop from the medium sets not only tended to be the largest, but it also ripened slightly earlier than that from the large cut and small sets.

Seed from Large and Small Plants.

As many growers still hold the opinion that improvement can be effected in a potato variety by taking sets from specially selected, large, strong growing plants, and that, conversely, deterioration can be brought about by selecting tubers continuously from small weak growing plants, a further series of experiments was carried out for the purpose of testing more fully and accurately how far these ideas are justified. In this case, a number of strong growing plants and a number of small plants were selected from an ordinary field crop of the same variety. *Special care was taken to see that all the selected plants were entirely free from disease.* Tubers of exactly the same size from each class were then taken and planted separately in drills alongside each other. In the first year it was found that the tubers from the strong growing plants gave rise to both large and small plants, as also did the plants from the small specimens. The same system of selection was practised in subsequent years—each year tubers from the best plants, the progeny of tubers from the best plants being selected on the one hand and the progeny of the smallest plants from tubers of the smallest plants on the other. An examination of the table of results shows that the average yield of tubers from the selected large plants at the commencement was 3 lbs. 11 ozs. and from the small selected plants only 12½ ozs. In subsequent years, however, the average yield per plant from both classes was almost identical and in the last year of the five-year experimental term was in the case of the large plant selection 2 lbs. 3 ozs. and in the case of the small plant selections 2 lbs. 2 ozs., the difference being almost entirely negligible and being more than covered by the ordinary experimental error.

A closer examination of the table of results showed, too, that in the case of the small plant selections quite as large a yield was had from some of the plants as from those in the large plant selections. Even after five years of continued selection along these lines the average yield from the large plants did not improve, neither was there any falling away in the yield from the selection of small plants. It is noted, too, that there was no difference in the average weight

of the tubers from the two series. These figures (I am quoting the text of the table of results) prove conclusively that no improvement has been effected by the continued selection of sets from large plants and that, so long as the plants are healthy, deterioration need not necessarily follow where sets from small plants are continuously used.

These results are quite in keeping with the ideas generally held at the present time regarding selection within pure lines. A potato variety or strain that has originated from one single plant is a pure line in the strictest sense of the term, and inside a pure line it has been proved that continued selection can effect no change. The only possibility of improvement or deterioration in the potato, or indeed in any plant that is progagated asexually, is where bud variation takes place, but all authorities agree that bud variation is so rare, except perhaps as regards colour, that it need scarcely be taken into consideration at all in this connection. It is true that many claim to have improved a pure strain by single plant or single tuber selection only, and have evidently succeeded in doing so, but in such cases it will probably be found that the weak plants dealt with were weak simply because they were attacked by some such disease as mosaic or leaf roll, or that the crop at the outset was really a mixture, and that the selection was what is known as "rogueing" and therefore any improvement effected was merely brought about by the elimination of the above quoted virus diseases or of inferior varieties.

Seed from Heavy and Light Crop.

A further series of experiments was conducted to find whether potato sets from a heavy crop would give a better return than seed from a light crop of the same variety and grown in the same soil. Five varieties were planted in a field where part was heavily manured and part left unmanured. At digging time tubers of the same size were selected from each plot. These were planted in alternate drills in a plot manured and cultivated in the same way, all over, so as to eliminate, as far as possible, any differences arising from inequalities in the condition of the soil. The result table shows that the seed was obtained from an average 12-ton crop from the manured section and six tons in the case of the unmanured section. In the following season, however, the yields from the seed from these two crops were practically the same, the average being 17 tons 4 cwts. and 17 tons 9 cwts. We see, therefore, that the treatment given to the crop from which the seed was originally selected had no effect whatever on the productive powers of the seed itself. Grown under the *same conditions of soil and manuring,* no permanent hereditary change has taken place leading either to improvement or to deterioration.

These results are interesting and go to show once again that deterioration is caused mainly by virus diseases. In these experiments it has been stressed that potatoes entirely free of disease had been picked as seed for the trials. The virus disease problem is not so great in Scotland as in some other countries, owing to the fact that the colder and perhaps more cultivated positions suppress many sucking insects which are responsible in the main for the transmission of such diseases. That better yields are obtained from the large and medium seed sets over those of the small sets has been demonstrated in this State in the summer-grown crop, but under our winter-planting conditions the size of the seed does not seem to be so important. This may be explained by the fact that the drier soil in the summer may draw some moisture away from the seed and the larger the set the more is it able to stand a certain amount of such drainage which would be detrimental in the case of the small set.

With the idea that seed potatoes from small plants, provided they are healthy, are just as good as seed from large plants, I am quite in accord, and this is demonstrated each year in the Denmark area. The seed crop for swamp planting is generally grown under adverse weather conditions from March to August and the tops in the main are small. Where sheltered conditions obtain growth is better, but the seed from the smaller plants does just as well as seed from the larger plants.

Now, under our climatic conditions we do find a weakening of vigour. This may or may not be temporary. In the case of our so-called "thready eye," where the tubers send out thin thread-like shoots instead of normal ones, if such are planted there is no progeny to carry on with. Where a weakening of growth takes place, as it often does if continually grown in light classes of soil, such weakening, if free of virus troubles, is temporary only and the vigour is regained if it is again planted in heavy soil. This is demonstrated by the fact that some of the potatoes produced in the lighter peaty swamps in the Albany area, when planted in the South-West in the hill crop, show quite weak, willowy growth, but when planted again in Benger Swamp or other heavy soil, the seed shows a "pick up" in vigour. There is little doubt that where crops mature in light soil under very high temperatures, as well as "thready eye," vigour temporarily suffers, but looking at the results of the experiments quoted we may consider that if a potato variety is kept pure and free from disease and is grown under suitable soil and climatic conditions there need be no deterioration. I may conclude by quoting that at Marybrook, near Busselton, some growers have not had a change of seed for ten years; attention has always been paid to rogueing of the seed plot, of course, and their crops are just as good, or better, now, than they were ten years ago. The winter and summer crops are grown on practically the same class of soil, but in spite of this the seed still retains its vigour, thereby suggesting that such soil and climatic conditions are suitable for continued production.

CLEAN MILK COMPETITIONS, 1937-38.

Conducted in the Balingup and Manjimup Districts.

B. Williams, Agricultural Adviser (Dairy Branch).

During the last season from November to January, two Clean Milk Competitions have been conducted with the object of ascertaining the quality of milk as delivered to the cheese factories in Balingup and Manjimup, respectively, and, wherever possible, to improve upon the present high standard of production. The first competition of this nature to be held in the State was conducted at Balingup in 1936, the success of which was clearly evidenced by the resultant improvement in the quality of the milk being supplied for cheese-making.

In 1937 the Manjimup Dairy Produce Company made available a sum of £5 together with a trophy of the same value for a continuous competition to be held over a period of five years.

In order to retain permanent possession of the cup, a supplier must win the competition for two consecutive years or, alternatively, gain the highest aggregate of points over the five-year period.

It was arranged that the competition should be adjudicated by an officer of the Department of Agriculture, whose decision would be final and also would provide an opportunity for the Department to come into contact with any difficulties arising in those districts from which the milk supply was drawn.

In order to judge the reliability of each supplier in maintaining the standard of quality, it was necessary to make three visits to each cheese factory. Accordingly inspections were carried out at Balingup on the following dates:—16th November, 1937, 21st December, 1937, and 26th January, 1938; and at Manjimup on 18th November, 1937, 23rd December, 1937, and 27th January, 1938, respectively. The date of each visit was not announced, thus eliminating special precautions being taken in the production and handling of the milk; thus the samples taken were truly representative of the supply of each competitor.

The actual judging was based upon the results of two tests, one physical and the other biochemical. The former, the sediment test, is one in which 500 c.c. of milk are pumped through a fine cotton wool pad. This pad will remove any foreign materials, curds or slime from the milk and also absorb any colouring fluid, to some extent, which may be present, thus giving a visible indication of the quality of the sample. For the latter the reductase test was used. This involves the principle that the dye methylene blue, in suitable concentration, is discolourised by reducing substances naturally present in milk, when the quantity of available oxygen is exhausted by living bacteria. The rate at which lactic and other acids are formed, and the rate of decomposition of proteins and fats present in the milk is approximately proportional to the number of living bacteria present and the rate at which they are working—this latter factor depending very largely upon the temperature. Thus the keeping quality of a sample may be determined by noting the period necessary to reduce the colour of the methylene blue. Milk, it must be remembered, is an excellent medium for the growth of many types of bacteria. When gaining access to milk, many of these organisms will render it unfit for human food in a very short time, if the temperature is suitable to their growth. Thus the reductase test is in effect a measure of keeping quality based upon the initial contamination with bacteria and their subsequent rate of multiplication.

A standard procedure was adopted, using methylene blue of $\frac{1}{200000}$ concentration. One c.c. of this solution was placed in a test tube and 9 c.c. of the milk sample added, giving a final concentration of $\frac{1}{2000000}$ when the two were mixed. This quantity is sufficient to impart a light blue colour to the milk. The sample was held at room temperatures and examined every 15 minutes until the dye was entirely discolourised. The time was noted and points awarded as indicated by the graph included in this article. For the purpose of the competition, it was decided to allot a maximum of 40 points for the sediment test and 60 points for the reductase test. The scoring of the sediment pads was based upon the quantity and type of extraneous matter present, i.e., dust, hairs, scales, insects, curd, blood, chaff, etc., and the relative amount of injury which they may cause to the milk.

The following tables show the results obtained in the competition at each centre:—

TABLE 1.

BALINGUP CLEAN MILK COMPETITION.

Place.	Competitor.	November.			December.			January.			Grand Total. 300 Points.
		Sediment Test 40 Pts.	Reductase Test 60 Pts.	Total 100 Points.	Sediment Test 40 Pts.	Reductase Test 60 Pts.	Total 100 Points.	Sediment Test 40 Pts.	Reductase Test 60 Pts.	Total 100 Points.	
1	H. Scarr	34	40	74	39	60	99	37	60	97	270
2	G. Blythe	30	60	90	25	60	85	32	60	92	267
3	N. Baxter	33	60	93	32	40	72	39	60	99	264
4	W. Grime	23	60	83	31	19	50	32	60	92	225
5	E. Churchill	33	60	93	28	0	28	37	60	97	218

TABLE 2.

MANJIMUP CLEAN MILK COMPETITION.

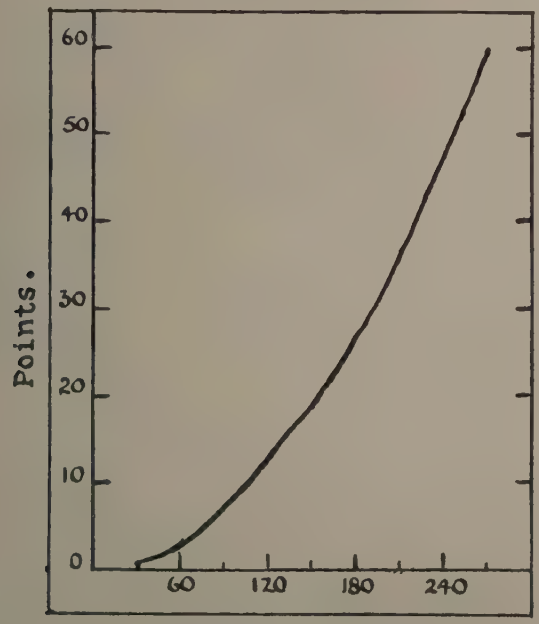
Place.	Competitor.	November.			December.			January.			Grand Total, 300 Points.
		Sediment Test 40 Pts.	Reductase Test 60 Pts.	Total 100 Points.	Sediment Test 40 Pts.	Reductase Test 60 Pts.	Total 100 Points.	Sediment Test 40 Pts.	Reductase Test 60 Pts.	Total 100 Points.	
1	Depot No. 1	35	60	95	35	60	95	33	60	93	283
2	R. Eaton	33	60	93	28	60	88	28	60	88	269
3	G. Pozzi	31	60	91	29	60	89	23	60	83	263
4	W. Arnott	35	60	95	24	60	84	20	60	80	259
	E. G. Austin	27	60	87	32	60	92	20	60	80	

The total number of entries received was 115, i.e., 38 in Balingup and 77 in Manjimup. The winners in each district are to be congratulated upon the production of a very high quality product which speaks well for their cleanliness and attention to detail so necessary in the warmer summer months.

The following graph shows the method of allotting points for the reductase test:—

Table 3

Reductase Test.



While conducting the tests, several points of importance became evident, and these may be summed up as follow:—

1. Sediments composed chiefly of fine dust, which had not dissolved into the milk, did not appear to impair keeping quality seriously.
2. Sediments containing hairs, scales, etc., indicated a milk of poor keeping quality.
3. Sediments containing albuminous and cheesy curds indicated a milk of very inferior keeping quality.
4. A general brownish discolouration of the pad indicated poor quality. Possibly dirty rinse water or blood from unhealthy cows would be the cause.
5. The mixing of night and morning milk in the one can causes quicker souring than either the night or morning milk separately.
6. Albuminous matter was most frequently traced to herds containing sick or freshly calved cows.
7. *The keeping of milk at low temperatures was by far the greatest assurance in maintaining a high standard of quality.* This point was very clearly shown on one occasion following a hot sultry night, when those farmers chilling their milk as a routine practice showed out to great advantage over those whose milk was not efficiently cooled.

The following tables show the number of suppliers delivering milk at the two centres and the number of good, fair, and poor quality samples obtained respectively.

In table 5 it will be noticed that the percentage of good quality milk rose from 21 per cent. to 37 per cent. over a period of three months, also the percentage of poor quality milk decreased from 34 per cent. to 10 per cent. over the same period. This clearly shows that, despite the drier and hotter conditions experienced in the summer, it is possible to obtain good results when special care is paid to sanitation and the maintenance of the minimum possible temperatures throughout all phases of production from the drawing of the milk from the udder to its delivery at the factory.

It will be noticed that, both at Balingup and Manjimup, the quantity of poor quality milk being delivered during December rose considerably. The reason for this was probably the hot sultry conditions experienced which were coincident with the time of testing and resulted in many samples scoring only low points in the reductase test. This alone is a very sound argument in favour of cooling the milk as soon as possible to as low a temperature as can be obtained.

Considering all competitors as a whole, it was pleasing to note that the amount of foreign material present in the samples, as shown by the sediment test, was considerably reduced in December and particularly in January. When one calls to mind the general conditions prevailing in these areas in January, one would expect to find a greater amount of foreign material, as the pastures are dry and the air is heavily laden with dust. This indicated that considerable attention was paid to the protection of the milk from the air and with good results.

TABLE 4.

ANALYSIS OF MILK SUPPLIED TO THE BALINGUP CHEESE FACTORY ACCORDING TO GRADE.

BALINGUP.

Grade.	Samples in each Grade.					
	November.		December.		January.	
	No.	%	No.	%	No.	%
Good—80–100 points	8	21	3	8	14	37
Fair —40–79 ,, ...	17	45	14	37	20	53
Poor — 0–39 ,, ...	13	34	21	55	4	10

TABLE 5.

ANALYSIS OF MILK SUPPLIED TO THE MANJIMUP CHEESE FACTORY ACCORDING TO GRADE.

MANJIMUP.

Grade.	Samples in each Grade.					
	November.		December.		January.	
	No.	%	No.	%	No.	%
Good—80–100 points	36	47	29	39	23	33
Fair —40–79 ,, ...	11	14	5	7	21	30
Poor — 0–39 ,, ...	30	39	40	54	25	37

TABLE 6.

TABLE SHOWING THE NUMBER AND PERCENTAGE OF SUPPLIERS IN EACH GRADE OVER A PERIOD OF THREE MONTHS.

Grade.	Balingup.		Manjimup.	
	No. of Suppliers.	Percentage.	No. of Suppliers.	Percentage.
Good—240–300 points	3	8	8	10
Fair —120–239 ,, ...	28	74	50	65
Poor — 0–120 ,, ...	7	18	19	25

The Competition has shown that it is not difficult to produce milk of high quality, provided that careful attention is paid to detail as regards cleanliness in every operation during its production and handling.

INOCULATION OF SHEEP AND CATTLE AGAINST TOXIC PARALYSIS.

The Department of Agriculture desires to advise farmers that it will no longer supply the vaccine for the inoculation of sheep and cattle against toxic paralysis. Persons desiring vaccine should forward their orders direct to the Chief Quarantine Officer (General), Department of Health, General Post Office Buildings, Perth, who will in future have control of supplies.

Owners are advised to inoculate their sheep and cattle during August or September in order to give them the necessary protection for the summer months.

THE PEA WEEVIL, BRUCHUS PISORUM (LINN).

By L. J. NEWMAN, Government Entomologist
and
H. G. ELLIOTT, Agricultural Adviser (Dairy Branch).

The spread of this pest has undoubtedly been brought about per medium of the sale and distribution of infested seed. In spite of the regulation which reads as follows:—"No person shall sell, supply, distribute, deliver or dispose of any field peas, to any other person, unless and until such field peas have been fumigated with Carbon-bisulphide in such manner as effectually to render the same free from the disease of Pea Weevil," there have undoubtedly been large quantities of infested seed sold and carried into previously clean areas.

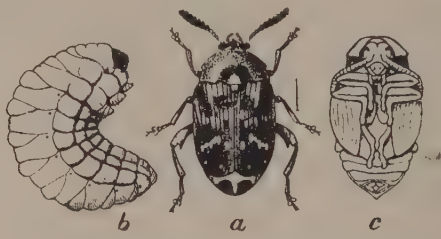


Fig. 1.—Pea Weevil: *a*, beetle; *b*, grub; c, pupa. True length of beetle shown by line at its right. (Chittenden U.S.D.A. *Yearbook*, 1898.)

The method of attack adopted by this insect renders control in the field economically impossible. The eggs are laid by the adult upon the outside of the young pea pod. The resultant larvae which issue immediately bore their way into the young developing seed and there ensconce themselves, slowly feeding and growing, reaching the adult winged stage when the seed matures.

The establishment of the Pea Weevil has rendered the growing of field peas (*Pisum spp.*) unprofitable for seed production.

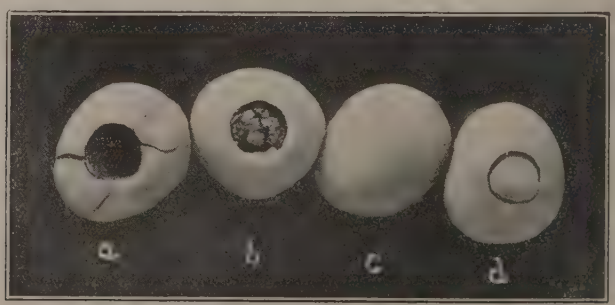


Fig. 2.—A.—Showing exit hole of adult weevil. B.—Adult weevil within pea ready to emerge. C. & D.—Infested peas showing typical indication of the weevil within.

Original.

The same insect also attacks the common garden pea but as this vegetable is eaten in the tender green stage, the young developing weevil grubs within are so tiny as not to affect the flavour or food value. If, however, the garden peas are allowed to mature their seed, the weevil will be found to be present in varying numbers according to the period of the year when they are grown, spring crops being the worst affected.

We have proved that this pest confines its attack to the field and does not, like grain weevils, continue to increase in storage. For further information concerning the life history and measures for control in stored seed, see the Departmental Leaflet No. 357.

In efforts to control this insect in the field, a series of planting trials was designed and carried out by the co-operation of the officers of the Dairying, Irrigation and Entomological branches during the 1936 season.

The object of these tests was to prove whether it was possible to overcome the trouble by varying the times of sowing The results were not conclusive but encouraged the belief that by departing from the normal planting period (July) and sowing later, the percentage of infestation of the seed could be considerably reduced if not entirely-prevented.

During 1937, a new set of field planting experiments was planned and carried out on the property owned and farmed by Mr. T. Tyrell, of Waterloo, situated on the South-Western Railway. The variety of pea used was that known as the Dunn Field Pea.

The variety usually grown in this area is the White Brunswick. The reason for using the Dunn Pea was that it was difficult to obtain weevil-free seed of the White Brunswick type.

An area of 1¼ acres, capable of being irrigated if necessary, was selected.

This land was previously under pasture, mainly subterranean clover and prior to that had grown field peas.

The land was divided into five ¼-acre plots and sown on the following dates:—

Plot 1. Normal planting period July 20th.
Plot 2. Sown August 16th.
Plot 3. Sown September 3rd.
Plot 4. Sown September 20th.
Plot 5. Sown October 4th.

The peas were planted at the rate of 2 bushels per acre with superphosphate 2 cwts. per acre on all plots.

The first four sowings were grown under natural rainfall. Plot 5 received one irrigation on the 23rd November but should the necessary late spring rains not eventuate it might be necessary to apply an earlier watering.

The plots were kept under careful observation during their growing period and the following results noted:—

1. That the normal July sowing and the August planting were seriously attacked and injured by Red Legged Earth Mite, Lucerne Flea, Looper Caterpillar, and Climbing Cut-worm.
2. That the early September sowing suffered in a progressively less degree from these pests.
3. That the late September and early October sowings were not seriously injured by these pests during their growing period.

In regard to the Pea Weevil, it was demonstrated that the crop from the mid-July planting was the most seriously affected. Up to 30 weevil eggs per pod were observed and most of the pea blossoms were damaged by the beetles feeding upon them. The August sowing, which podded in late October, was also found to be seriously infested, indicating that planting during that month did not overcome the trouble, the adult weevils continuing to be active. The September and October plantings flowered and podded during November and early December showing considerably less infestation.

When the crops ripened a representative sample of seed was gathered from each plot and carefully examined for the presence of weevil.

Plot 1. Normal mid-July sowing showed 92.5% infested seed.

Plot 2. Mid-August planting 73% infested seed.

Plot 3. Early September sowing 42% infested seed.

Plot 4. Late September sowing 45% infested. This is a slight rise on the early September planting which experimentally could be regarded as negligible.

Plot 5. Early October sowing 9% infested seed.

Summarising the results, it was found that the early sown peas are more susceptible to the attack of Red Legged Earth Mite, Lucerne Flea, Looper Caterpillars, Climbing Cut-worms and Pea Weevil.

Observations of the crop yields of each plot indicated that the variation in the planting periods did not reduce the returns per acre.

The extra cost involved in the one irrigation of the October-sown crop was offset by the greatly lessened percentage of weevil infested peas stripped. The possibility of using this information may provide in the wetter and irrigable areas a means of reducing the serious damage caused by the Pea Weevil and the other pests mentioned.

The Department proposes to continue these experiments on a larger scale during the coming season.

Further, in an effort to determine whether the weevil could be overcome by substituting other fodder plants the following were experimentally tested at the Denmark Agricultural Research Station:—

1. Tangier Pea (*Lathyrus tangitanus*).
2. *Lathyrus sativa.*
3. *Lathyrus annus.*
4. *Vicia sativa.*
5. *Vicia atropurpurea.*
6. *Vicia monantha.*
7. Grey seeded Vetch (*Vicia sp.*).
8. Small seeded Horse or Tick Bean (*Vicia faba*).
9. Lentil (*Ervum lens*).
10. Austrian Winter Pea (*Pisum arvense*).

The growth of these crops was closely watched. When ripe a representative sample of seed was collected and with the exception of the Austrian Winter Pea (*Pisum arvense*) were found to be immune to Pea Weevil (*Bruchus pisorum*). It was thus demonstrated that this pest confines its attack to the *Pisum* group of peas.

The most outstanding varieties of those tested were the small seeded Horse or Tick Bean, Tangier Pea, *Vicia sativa*, *Lathyrus annus*, and the Grey-seeded Vetch.

M. T. PADBURY TROPHY COMPETITION.

I. Thomas, Superintendent of Wheat Farming.

This competition, which is organised by the Royal Agricultural Society, was inaugurated in 1930, and was made possible by a generous donation by Mr. M. T. Padbury, a pioneer farmer of this State.

The trophy is a handsome shield and will be awarded to the competitor gaining the highest average yield of wheat per inch of rainfall during the conventional growing period (May to October) for any five years during the period of the competition (10 years). The winner of each year's competition is, however, presented with a replica of the trophy.

The conditions under which the competition is conducted are as follow:—

1. The competition will commence with the 1930-31 harvest and continue for a period of 10 years. At the end of that period the trophy will be awarded to the competitor who has taken part in the competition for at least five years, and who obtains the greatest mean average acre yield per inch of rainfall during the conventional growing period. The mean average yield will be computed from the results of the five seasons in which the competitor produced the highest acre-yield per inch of rainfall during the growing period. In the event of a tie the competition will continue between the leading competitors until an advantage is gained by one of them.

2. The conventional growing period for any year will be that decided upon and announced by the Royal Agricultural Society. For the first year, and until further notice, it was decided that it would be from 1st May to 31st October, inclusive.

3. Until the end of the competition the trophy will be in the custody of the Royal Agricultural Society, and will be displayed at any agricultural exhibition held by that society.

4. Each year the competitor who obtains the best average acre yield per inch of rainfall during the conventional growing period will be awarded a replica of the trophy. His name will also be inscribed upon a small shield affixed to the trophy.

5. The rainfall upon which the award will be made will be determined by the Commonwealth Meteorologist from the district records, and his decision in this matter will be final.

6. The competition will be limited to those farmers who harvest at least 200 acres of wheat for grain. Where a competitor is financially interested in the crops grown on one or more farms, he will be required to supply details regarding the production and marketing of the crops on same, and, though usually the award will be made upon the results from the farm nominated by the competitor, the Royal Agricultural Society may require that the crops on these farms be included in the competing area.

7. The average yield will be ascertained from the total area —including self-sown crops—harvested for grain, and determined from the actual amount of

wheat sold, as shown by the delivery dockets, plus the amount retained for seed, for home use or for any other purpose.

8. The method of judging will be as follows:—At a convenient time the area harvested for grain will be measured and the quantity of wheat on hand ascertained. On or before 31st January the farmer will be required to furnish the judge with a sworn declaration as to the quantity of wheat sold from the competing holding or holdings, and the amount retained for seed and other purposes; the statement regarding the amount sold to be supported by agents' dockets. The judge, after satisfying himself as to the correctness of this statement, will compute the average yield per acre per inch of rainfall during the growing period from the information received.

9. The judge will be appointed by the Director of Agriculture, and his decision will be final.

10. Nominations for this competition will be received by the Royal Agricultural Society up to the 31st October each year.

The eighth year of the competition has been completed with the 1937-38 harvest and the results for that season are now finalised. The winner was Mr. R. M. Jones, of Shackleton, with the excellent average yield of 3 bushels 16 lbs. per inch of rainfall from an area of 241 acres. He was closely followed by the previous year's winner—Mr. F. C. West, of Toompup—with 3 bushels 7 lbs., and the Hon. T. Moore, of Indarra, the winner in 1935, with 3 bushels 2 lbs.

The results for last season (1937-38) are given in the table below:—

M. T. PADBURY TROPHY COMPETITION.

1937-38.

Competitor.	Address.	Rainfall during Growing Period.	Area Harvested.	Yield.					
				Gross.		Average per Acre.		Average per inch Growing Period Rain.	
		points.	acres.	bus.	lbs.	bus.	lbs.	bus.	lbs.
Jones, R. M.	Shackleton	665	241	5,229	24	21	42	3	16
West, F. C.	Toompup	1,027	218	6,976	27	32	0	3	7
Moore, Hon. T.	Indarra	904	246	6,758	24	27	28	3	2
Bland, C. O.*	Corinthian	470	753	9,330	0	12	23	2	42
McCormack, T. B.	Nungarin	717	375	6,391	0	17	25	2	26
Perkins, C. C.	Belka	670	789	12,252	24	15	32	2	19
Barr, D. F.	Shackleton	715	482	7,869	24	16	19	2	17
Bremner, J. R. & Sons	Corrigin	744	874	14,441	6	16	31	2	13
Creagh Bros., Ltd.	Nungarin	632	1,007	13,437	42	13	21	2	7

* This entry suffered losses from hail damage, but, under the conditions of the competition, any assessed losses cannot be included in the yields.

The average yield per acre of the nine entrants was 19 bushels 11 lbs., and the average yield per inch of rainfall during the growing period was 2 bushels 37 lbs.

In Table 2 particulars are given of those competitors who have taken part in the competition for three years or more and, therefore, are still able to compete

for the requisite five years, as stipulated in the conditions, before the termination of the competition with the 1939-40 harvest:—

M. T. PADBURY TROPHY RESULTS, 1930-37 (INCLUSIVE).

Competitors who have Competed for three or more years.

Competitor.	Address.	Average Yield per inch of Growing Period Rainfall.							
		1930.	1931.	1932.	1933.	1934.	1935.	1936.	1937.
		bus. lb.	bus. lb.	bus. lb.	bus. lb.	bus. lb.	bus. lb.	bus. lb.	bus. lb.
Allen Bros.	East Kumminin	2 11	2 23	....	2 26	3 1	....	....	....
Atkins, F. M. & J. L.	Jouerdine ...	2 41	3 0	....	3 39	4 29	....	....	....
Barnett, L. T. C.	Walgoolan	2 48	2 19	2 34	2 58	....	....	....	....
Bremner, J. R. & Sons	Corrigin	1 55	2 10	1 48	2 32	2 37	2 12	1 49	2 13
Butcher, O. J.	Pithara	....	....	2 42	1 58	4 8	....	....	....
Creagh Bros. Ltd.	Nungarin	2 20	2 16	1 43	2 12	2 41	....	....	2 7
Horsman, H. & Sons....	Bilbarin	1 53	2 6	1 5	2 49	....	....	....	....
Manuel, C. J.	Mukinbudin	2 44	2 10	2 5	2 5	3 4	..	..	....
Moore, Hon. T.	Indarra	....	2 47	2 33	3 5	....	4 6	....	3 2
Nottage, R. B.	Tammin	....	2 36	2 21	3 23	4 13	....	..	....
Prowse, E. W.	Doodlakine	1 42	....	1 31	....	3 13	..	.	.
Scadding, N. A.	Kulin	....	....	2 4	2 10	2 49	2 27	1 35	..
Smith, C. & Sons	Yarding	2 21	2 29	....	....	3 57	....	.	.
Snell, C. & Son	Nangeenan	2 29	....	....	2 54	2 37	..	..	. .
Stewart, W. B.	Gnowangerup....	1 52	2 37	1 54	2 55	2 30	....	....	. .
Strange, P. A.	Yarding	2 36	2 6	....	2 48	2 33	....	1 48	. .
White, R. H.	Gnowangerup....	1 51	2 45	....	2 40	2 47	2 25	....	..
Williams, F. A.	Mangowine	3 23	2 25	1 34	....	....	....		.

CYSTS IN SHEEP.

A. McK. CLARK, L.V.Sc.,
Chief Veterinary Surgeon.

The attention of sheep breeders is drawn to the infestation of sheep with tapeworm cysts. It is reported that up to 12 per cent. of the carcases from some flocks are infested. The position is so serious that some effort should be made to minimise this infestation so as to avoid the great economic loss which is occurring, and which will continue unless some effort is made to prevent this infestation. Fortunately, the methods of prevention are not difficult, but require that the dogs, and particularly sheep dogs, should be treated at least once in three months.

The tapeworm cyst (*Cysticercus ovis*) is a cloudy coloured bladder-like formation distended with fluid which may be seen particularly on the outer surface of the liver. It is also found deeply seated in the heart and other muscles. These cysts are the intermediate stage in the life cycle of the tapeworm (*Taenia ovis*) of the dog. The dog, and particularly the sheep dog—because of its association with sheep—is spreading the cyst through depositing the tapeworm segments in the water supplies or on the pastures in its droppings. From there they are taken up by the sheep. It is obvious, therefore, that in order to minimise the infestation of sheep with these segments the dog should be rid of the worm by treatment. It is recommended that dogs should be treated at least once in three months with 2 grains of powdered Areca nut for every pound of the dog's weight, or 1 grain of Arecoline Hydrobromide dissolved in 2 ounces of water; give one tablespoonful of this solution as a dose for a 20lb. dog. The whole course of this treatment will not cost more than 6d. per annum. Care should also be taken that dogs are fed only with cooked meat.

FERTILISERS—ADDITIONAL REGISTRATIONS.

The last March issue of this Journal contains a list of additional registrations of fertilisers, to that contained in the December issue, for the current year together with the minimum percentages of the fertilising ingredients. Further additional registrations, with the respective analyses, are shown in the following table:—

Name of Fertiliser.	Reg. No.	Brand.	By Whom Registered.	Nitrogen (N) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O) as		Cash Price per ton on Rails, Perth.
				Nitrate.	Ammonia.	Blood and Bone.	Bone-dust.	Water Sol.	Citrate Sol.	Acid Sol.	Total.	Sulphate.	Muriate.	
				%	%	%	%	%	%	%	%	%	%	£ s. d.
Fertiliser	144	Apollo	J. Kitchen & Sons Pty., Ltd.	....	....	7·0	....	....	14·0	....	14·0	....	....	10 7 6
Blood and Bone	145	Riverstone	Riverstone Meat Co. Pty., Ltd.	..	....	5·5	....	..	5·0	9·25	14·25	..	....	7 5 0†
Dried Blood	146	do.	do. do. do.	.	....	13·0	....	..	....	....	....	....	....	13 10 0†
Blood and Bone	147	Albany Freezing Works	Albany Freezing Works, Ltd.	..	....	6·0	....	....	....	..	12·0	..	..	9 10 0*
Phosphatic Guano	148	Cormo	M. F. Philips, Shark Bay	....	....	....	1·37	....	....	....	23·89	....	....	a
Fish Fertiliser	149	do.	do. do. do.	....	..	..	6·2	....	....	.	6·2	..	....	a
Blood and Bone	150	Robb's	West Australian Meat Export Co., Ltd.	....	....	5·25	....	....	....	....	14·0	....	....	9 [illegible] 0
Potato Manure	151	Eclipse .. .	do. do. do.	....	3·0		....	16·0	....	0·25	16·25	4·25		7 10 0
B.S.P.	152	do.	do. do. do.	....	1·2	....	....	5·0	....	9·0	14·0	....	1·2	5 5 0

† Price f.o.b. Sydney. * Price ex works. a Price on application.

PREPARING SHEEPSKINS FOR MARKET.

By Hugh McCallum,
Sheep and Wool Inspector.

There is great need for more care in the treatment and packing of sheepskins for market. Many consignments forwarded for sale are carelessly prepared and consequently receive a lower classification. This is unnecessary and reveals bad management. A little more care on the part of the farmer will result in a handsome profit due to the increased price per pound of the consignment.

Fig. 1.—Skinning the carcase.

Except in the cases of skins from dead sheep, tabby and grass seed pierced skins, any classed as "damaged" indicate bad methods of skinning, drying, preserving or packing. These methods may result in cut or torn skins, weevil eaten, sun dried or shrunken and wrinkled skins.

The losses incurred by forwarding these inferior skins for sale may be easily avoided if, in preparing the skins, the following general methods are adopted by the farmer.

SKINNING.

Excessive use of the knife is a bad practice, and with accomplished skinners its use is restricted to as few parts as possible. It is usual to commence by inserting the knife under the skin at the base of the forelegs and opening down to the point of the brisket, then up the throat, the other forelegs being done similarly. The

Fig. 2.—Final operation of skinning.

skin should be lifted off the brisket and punched off over the belly, finally cutting down from the hocks to under the tail and skinning around the butt. From this point there is usually no further need of the knife for skinning, only for cutting. When the sheep is on the hooks the skin is cut down from between the legs to the brisket and then carefully pulled off from the back with puncher's, down to the back of the head and cut off with the ears still attached. See Figs. 1 and 2. By

punching wherever possible the danger of cutting the pelt and the likelihood of attachments of fat, which make preserving difficult, is decreased. It is very desirable to prevent the wool from becoming bloodstained, and this is facilitated by allowing the sheep to bleed fully before commencing to skin. Wash off all blood before it dries and wring out the wool.

DRYING AND PRESERVING.

The fresh skin should be stretched out flat under shelter in a desirable shape as indicated by fig. 3. Care should be taken to prevent the edges of the pelt rolling in and it should be stretched out well at the neck. It usually takes six or more

Fig. 3.—Laying out the skin.

hours for the pelt to set and it should then be painted with an anti-weevil solution. See Fig. 4. Special care should be taken in painting the edges and neck. There are many effective arsenical washes being used for this purpose. A solution of sheep dip, too, is suitable.

Although the above method is preferable, in some cases there is a shortage of available floor space and fresh skins can be placed over rails. See Fig. 5. Never store skins on top of one another as they sweat.

When the paint is dry the skin should be hung lengthwise over a rail under shelter with flesh side up, allowing the trotters and legs to hang down either side.

See Fig. 6. Not as in Fig. 7. The skin should be sheltered from sun and rain, both of which damage the pelt.

PACKING.

When the skins are dry and there are sufficient to make a bundle, all trotters should be cut off and the skins folded along the back line with the wool outwards. See Fig. 8. They should be placed on top of each other with the folded back line alternately on either side. The neck end should also be alternated and all ends tucked in. See Figs. 9 and 10. The bundle can be weighted or levered down and

Fig. 4.—Painting with arsenical solution.

should be secured by wire. See Figs. 11 and 12. Rope or binder twine is not recommended as fibre is liable to be left in the wool. The finished bundle should be compact, neat and easy to handle. See Figs. 13 and 14.

In consigning them the broker should be advised of the number of skins, each bundle being labelled separately. It is important that the loose ends be folded in, as they may be used by handlers for shifting the bundles, with a possible consequence that the skins are torn.

Fig. 5.—Placing the skin on a rack.

Fig. 6.—Skin properly hung to dry.

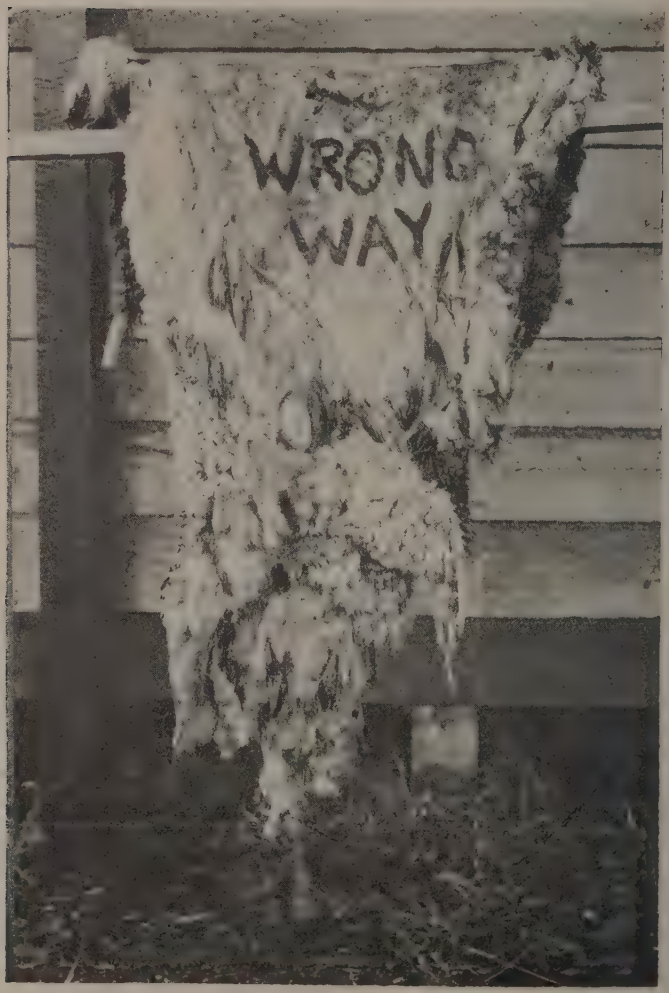


Fig. 7.—The wrong way.

Fig. 8.—Folding the dry skin.

Fig. 9.—Properly folded.

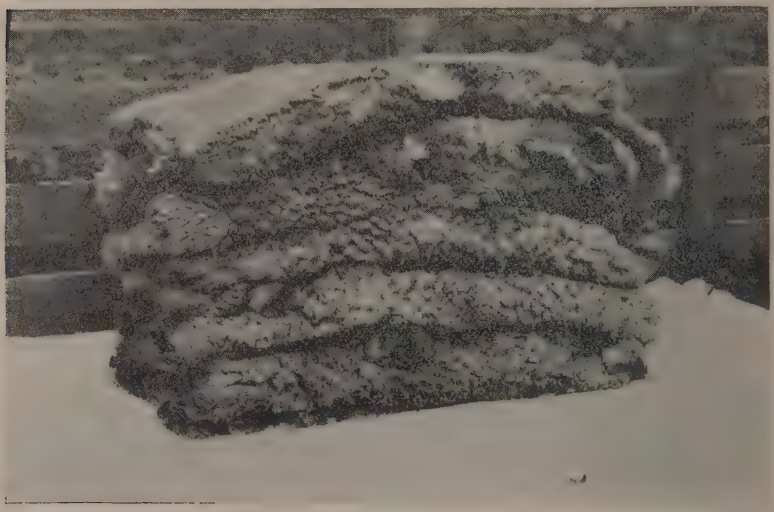


Fig. 10.—Stacking for packing.

Fig. 11.—Pressing.

Fig. 12.—Wiring.

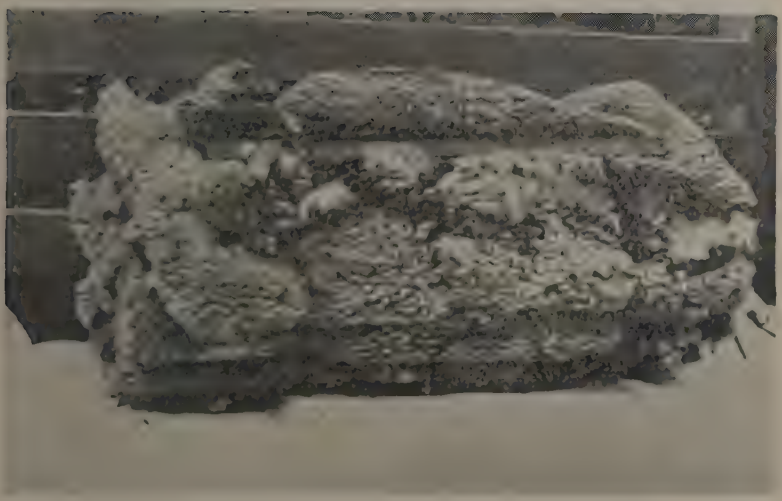


Fig. 13.—The bundle completed.

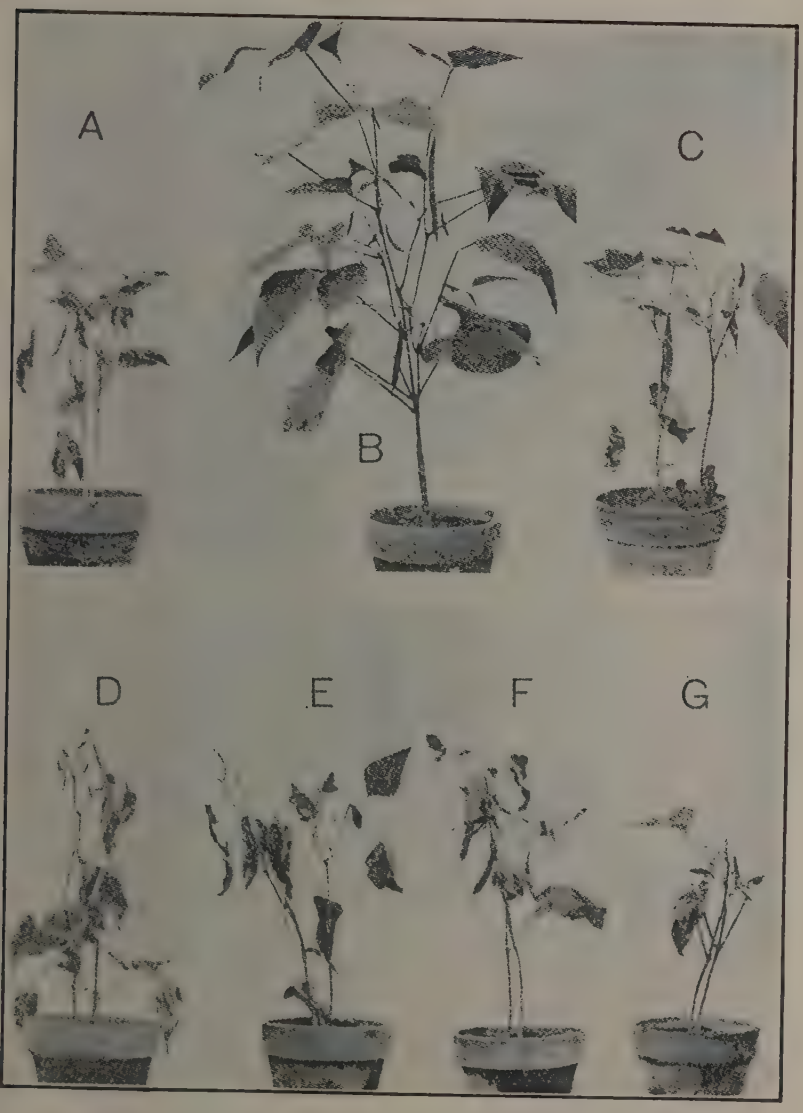
Fig. 14.—Ready for market.

BACTERIAL BLIGHT OF BEANS.

H. A. J. PITTMAN, B.A., B.Sc.Agr. (Hons.), Dip.Ed.,
Plant Pathologist.

Prior to the 1930-31 season the "Canadian Wonder" bean crops (*Phaseolus vulgaris*, L.) in this State had always been, so far as is known, quite free from any bacterial disease. In November, 1930, however, complete losses of crops of this variety were caused at Maddington, by a disease which was readily diagnosed as a "bacterial blight," the major part of the losses, if indeed not all, apparently being due to the bacterium known as *Phytomonas medicaginis* var. *phaseolicola*. The seed from which these crops were grown had been obtained from Orbost, Victoria, where a huge bean seed-raising industry had been established, which at that time supplied practically all the "Canadian Wonder" bean seed planted in Australia.

Shortly after the first outbreak of the disease in this State, news came to hand per medium of the Eastern States press that total crop failures had been reported during the 1930-31 season from South Australia and many parts of Victoria, due



ig. 1.—Wilts of "Red Kidney" bean plants one month after inoculation with various bacterial pathogenes.

The plants were inoculated at the first leaf node. A, *Phytomonas medicaginis* var. *sascholcola;* B, check; C, *Phyt. phaseoli* var. *fuscans;* D and E, two strains of *Phyt. haseoli;* F and G, two strains of *Phyt. flaccumfaciens.*

B represents a perfectly healthy uninoculated control plant photographed on the ame scale as the others.

(*After* Burkholder, "*The Bacterial Diseases of the Bean,*" *Cornell University gric. Expt. Sta. Memoir* 127, *April,* 1930.)

to the ravages of a bacterial blight. This disease, caused by *Phytomonas medicaginis* var. *phaseolicola*, has since been reported from New Zea and (W. D. Reid, N.Z. *Journ. Agric.* Vol. 43, No. 6, Dec., 1931, pp. 408-415) and Queensland (L. F.

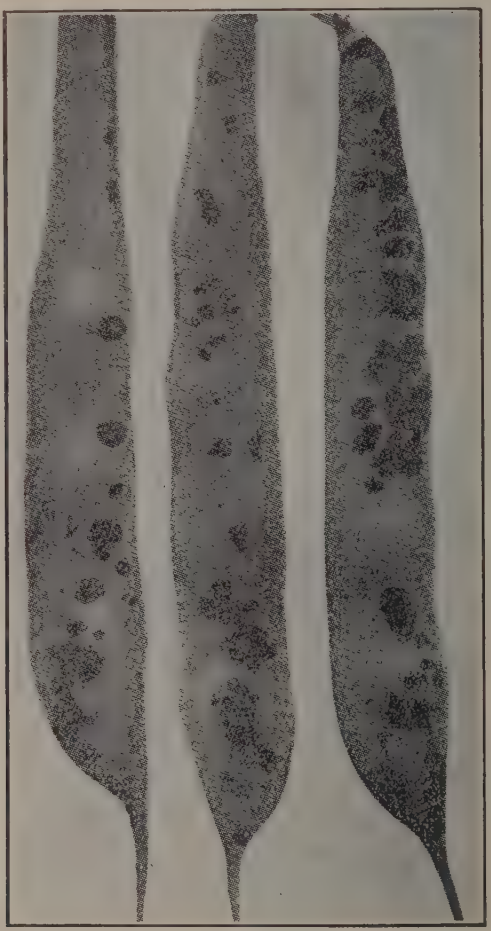


Fig. 2.—Pods of "Red Kidney" bean showing lesions caused by *Phytomonas medicaginis* var. *phaseolicola*.
(*After Burkholder, "The Bacterial Diseases of the Bean," Cornell University Agric. Expt. Sta. Memoir* 127, *April*, 1930.)

Mandelson, Queensl. *Agric. Journ.*, Vol. 37, Part 2, pp. 128-33, Feb. 1932), and it has led to very severe losses in the big bean-growing district of Gosford, New South Wales.

Samuel (*Journ., Dept. Agric.*, South Aus., Vol. 34, No. 7, Feb., 1931, p. 746) records a bacterial spot of beans in South Australia as being probably due to *Phytomonas medicaginis* var. *phaseolicola*.

Since the first occurrence of the disease in this State, devastating losses have occurred at Nedlands in extra early crops of "Canadian Wonder" beans, and also of the same variety at Geraldton, Balcatta, Spearwood, and other places where market-gardening activities are extensively practised.

SYMPTOMS OF THE DISEASE.

On entering a field severely affected with bacterial blight, the first impression gained is that the germination has been very irregular, and that the affected plants are suffering from nitrogen starvation combined with the effects of an exceedingly severe drying wind, although it may be very well known to the observer that neither of these things could possibly be the cause of the trouble. In a number of patches where the disease obviously first appeared, all that will be left of the affected plants will be a few stiff stems with shrivelled and dried-out leaflets still hanging to, in some cases, or else fallen from, the leaf stalks or petioles, which usually remain stiffly erect. A number of the plants may have grown little, if any, further than the seed-leaf stage.

A number of the leaves may have fallen away from the plants at the abscission layer near the base of the leaf-stalk (petiole), while in other cases the leaflets will have dropped off with their own stalks (petiolules), leaving the petioles projecting stiffly into the air. The swellings at the base of infected petioles may be very much watersoaked in appearance and still quite green, even though the end of the petiole is browned and shrivelled.

If the weather conditions are moist at the time, or if the plants are growing in very moist situation, or have been recently heavily watered with a sprinkler, beads of bacterial slime may be found exuding from the joints or nodes on the stem, just below the bases of the petioles, or from the wounds left by the falling away of the leaflets, leaves or cotyledons (seed leaves). Elongated, very irregular, slightly sunken, brown lesions with a reddish-brown margin may occur on the stem, and a more or less complete brown girdling of the stem with a reddish margin and considerable bacterial ooze may be located at the point where the seed leaves were formerly situated. Some of the leaflets which have not yet dried out may show a considerable number of rusty-brown, more or less confluent, small irregular lesions between the veins, the remainder of the leaflet having a very sickly, nitrogen-starved, mottled appearance. Such leaves are frequently very ragged at the margins and "shot-holed" in appearance. Small, dark-green, watersoaked, or brownish dead areas may occur on the leaflets, each spot being surrounded by a comparatively enormous pale-green halo. The presence of this characteristic halo has led to the disease being known elsewhere as "Halo Blight."

Affected *pods* may show one to very numerous more or less circular dark green watersoaked lesions, from which bacteria may exude in beads in moist weather, in a very moist situation, or when placed for a day or so in a moist jar. These areas later on may dry out and become more or less reddish or brown in colour. The diseased areas may run together and cause malformation and withering of the infected pods.

Early sown and late autumn crops are generally the most severely affected, as cool, moist, atmospheric conditions are more favourable for the spread of the disease than hot, dry conditions. The danger from bacterial blight is greatest in the localities which would otherwise be the most suitable for the production of very early crops, that is in the frost-free coastal areas and picked spots close to the Swan River or other favoured locations. The disease is apparently spread about

in the field from the primarily-infected plants by driving rain, hail, overhead watering, insects, or cultivation and harvesting operations when the plants are in a moist condition. The spread of the disease in the field under suitable conditions may be exceedingly rapid.

CONTROL.

The disease is carried by the seed, and the only known control measures are to plant seed harvested from disease-free crops, on new land, or land that has not grown an infected crop for at least three years; or to plant resistant or immune varieties.

Since infection is not only carried on the outside of the seed, but actually in a number of cases inside the seed coat, adequate seed disinfection is impossible, as any treatment severe enough to kill the bacteria within the seed coats would also kill the seed.

The appearance of the seed may give no indication as to whether the disease is present or not, as perfectly healthy-looking seed may be carrying sufficient infection to give total crop failure under suitable climatic conditions.

Bacterial blight can only be detected with any degree of certainty in the seed by a long and tedious laboratory investigation, or, better still, by actually growing a representative sample of the seed in disease-free soil prior to the planting of the bulk, and carefully observing the test seedlings for any signs of disease. In the seedlings bacterial blight may be recognised as small diseased spots which develop on the cotyledons (or seed leaves), which are attached to the top of the stem when the seedling stem appears above ground.

In view of the disastrous result that almost inevitably attends the introduction of even a small percentage of infected seed on to a property, **growers who know that their land and crops are clean are strongly advised to raise their own seed, even though it may be contrary to their practice and inclination to do so.** It is important to remember that bacterial blight is carried almost solely by the seed, and properties that are now clean may therefore be kept so perhaps indefinitely by the expedient of planting only clean seed.

Clean seed may be obtained from an originally diseased line, by growing a crop during the hot dry weather, provided that artificial waterings, if necessary at all, are kept down to the irreducible minimum, and that the diseased plants are pulled out and burnt as soon as noticed. To inhibit spread of the disease from affected to healthy plants the seed should be much more widely spaced than if a commercial crop were being grown. Frequent inspections should be made as soon as the seed has germinated, and any weak or sickly plants, as well as plants with spotted seed leaves, or with blight spots on the leaves or stems, should be carefully removed and immediately destroyed by fire or boiling, the hands then being carefully washed several times in carbolic soap or rinsed in methylated spirits before handling healthy plants. Bean plants should never be worked amongst when any moisture is present on the leaves, as infection may easily be spread in this way.

The plants being grown for seed purposes should be sprayed frequently with 4-4-50 Zinc Bordeaux Mixture, prepared in the usual way except that half of the copper sulphate normally used is replaced by an equal weight of zinc sulphate. (See Leaflet 314.)

Growers whose crops are infected should burn all diseased plants, and should not plant the infected land to any susceptible variety of beans for at least three years.

Regarding varietal susceptibility, Dr. R. J. Noble, Biologist, Department of Agriculture, New South Wales, in a letter to the writer dated 13th November, 1931, says—

"Bacterial blight of bean has been very prevalent in this State during the last two seasons, and at present is so widespread in Canadian Wonder crops that only limited supplies of beans are reaching the market. The disease first came under notice in this State in 1928.

"Field observations have been made by this Department on relative resistance in about 200 varieties and selections of beans for two seasons, *but no variety has shown outstanding resistance.*

"*Kentucky Wonder* and *Epicure* pole beans have been among the most resistant.

"Most lots of Canadian Wonder bean seed on the New South Wales market at present are infected to a greater or lesser extent, but most of the fancy beans are blight-free so far . . . . . It is understood that most of the seed of the fancy types is imported from overseas.

"It is considered that beans will continue to be a very unsafe crop until disease-free seed can be raised."

Mr. D. B. Adam, formerly Plant Pathologist of the Victorian Department of Agriculture, now Plant Pathologist to the Waite Agricultural Research Institute, Adelaide, in a letter to the writer dated 16th November, 1931, advises that—

" . . . . . field observations suggest that the green bush beans 'Pale Dun' and 'Feltham's Prolific' are more resistant to bacterial blight than the 'Canadian Wonder.' The green bean trade is not so keen on these varieties because the pods in the case of 'Pale Dun' are smaller, and in the case of 'Feltham's Prolific' less fleshy than those of 'Canadian Wonder.'

"Among waxpod or butter beans we find that the 'Startler,' though certainly not immune from bacterial blight, is fairly resistant."

Observations made by the writer at Geraldton several years ago amply bore out the contention that "Feltham's Prolific" is much more resistant to "Halo Blight" than "Canadian Wonder." Double rows of seed had been planted, the right hand side being of the one variety and the left hand side being of the other. The seeds of each variety were planted only about 3 inches apart so that the two varieties grew up intimately mixed together. The "Canadian Wonder" were wiped out at a very early age but the "Feltham's Prolific" were a nice deep green colour, grew and yielded well, and although affected to some extent on the leaves, stems and pods, picked a very satisfactory commercial crop.

The white-seeded runner bean which appears to be nameless, but which is so commonly grown at Balcatta, Wanneroo, Osborne Park, and other parts of the metropolitan area and adjoining districts nowadays, has saved the situation in this State, as it appears to be absolutely immune, no plant of this variety ever having been seen by the writer carrying lesions, even when grown alongside crops of "Canadian Wonder" which have been wiped out, or planted on heavily infected land. This bean is not as early maturing as the "Canadian Wonder," but in every other respect provides a satisfactory substitute.

In conclusion, I cannot too strongly emphasise that unless growers can obtain absolutely disease-free seed (as, for example, seed certified by a Government Department of Agriculture to be blight-free), and plant it on disease-free soil, they would be very well advised to give up growing "Canadian Wonder" beans altogether, and confine their attention to the other varieties mentioned above as being somewhat resistant or immune.

A COMPARISON OF THE "WHOLEMEAL FERMENTATION TIME" TEST AND FARINOGRAPH TEST FOR FLOUR QUALITY.

L. W. SAMUEL,
Cereal Research Officer.

Of recent years two tests for the baking quality of wheat and flour that have received considerable attention are: 1, the wholemeal fermentation time test, or Pelshenke test; and 2, the Farinograph.

METHODS.

1. The wholemeal fermentation time test was described by Pelshenke (1930-31) and by Cutler and Worzella (1931), and since then numerous workers have reported the results of its application to the evaluation of the baking quality of wheat.

For the comparison reported in this paper the test was made in triplicate using 5 g. of meal ground in a Wiley mill with a 1 mm. sieve and using 2.7 mls. of a yeast suspension made by dispersing 10 g. of compressed yeast in 108 mls. of distilled water. The doughballs were immersed in 150 mls. of distilled water in a 250 ml. beaker maintained at a constant temperature of 32 deg. C.

The time taken for the doughball to rise to the surface was always noted as a check on the activity of the yeast and was not more than 15 mins.

Nitrogen was determined by the Kjeldahl method and the factor 5.83 used to convert nitrogen into protein which was then expressed on a 13.5 per cent. moisture basis and used in the calculation of specific protein quality, the time in minutes per gram of protein.

Moisture was determined by drying for one hour at 130 deg. C.

The "time" test thus yields three values, the time in minutes for the first piece to be detached from the doughball, the protein content and the specific protein quality.

2. The Farinograph of the Brabender Elektromaschinen O.H., patented in England by Hankoczy (Brit. Patent 340297, 29/8/29), is essentially a recording dough mixer which records graphically the power necessary to mix a dough of standard maximum consistency and records the change in this power with continued mixing. The type of graph obtained is shown in fig. 1 and from this graph three values were obtained for comparison with the fermentation time test.

(a) The water absorption (corrected to a 13.5 per cent. moisture basis) necessary to form a dough with a maximum consistency of 500 units;

(b) the strength figure of the flour, being the time in minutes for the top of the graph to fall below the maximum consistency of 500 units;

(c) the dough weakening, being the number of consistency units by which the median line of the graph has fallen below the maximum consistency after 10 mins. mixing.

The water absorption was first determined by trial and then in the experiment mixing was continued until the top of the graph had fallen below the maximum consistency line.

MATERIALS.

The wheats used in this investigation were the individual varieties entered in the wheat section of the Royal Agricultural Society's Show, 1937, and were thus of the 1936-37 season. There were 65 entries representing 17 varieties and all were subjected to the wholemeal fermentation time test in the Government Chemical

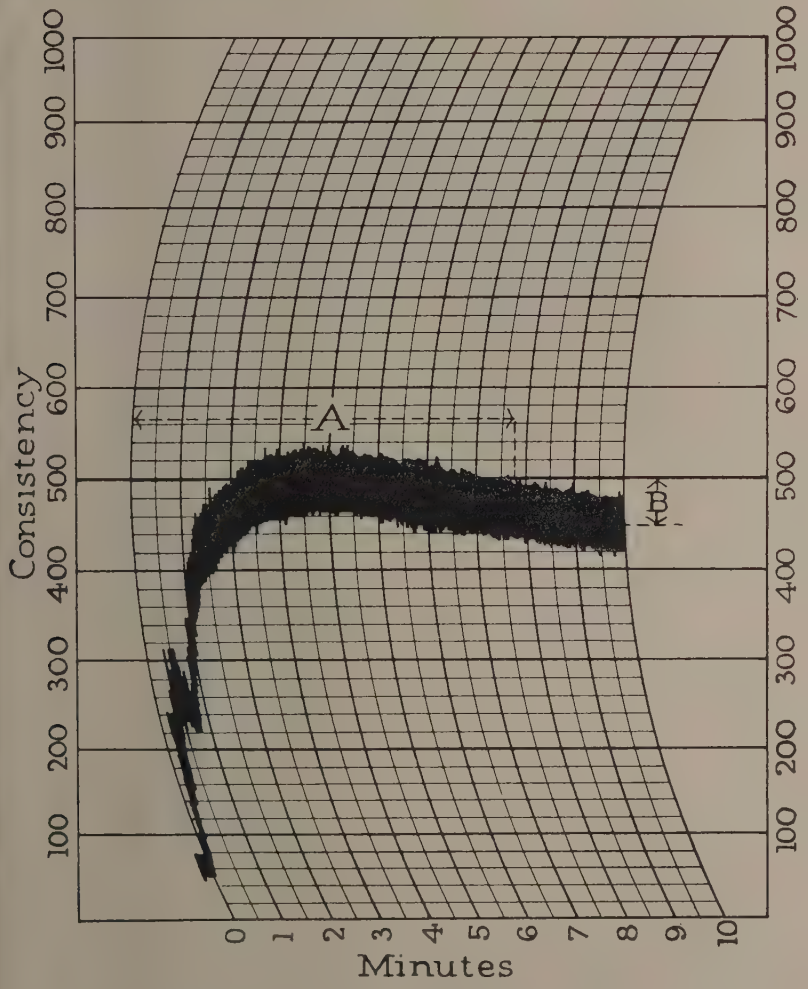


Fig. 1.—Specimen farinogram—A, strength figure; B, dough weakening.

Laboratory. Only 28 of these wheats were milled on the Brabender experimental mill and tested in the Farinograph. The approximate flour extraction was noted and the flours analysed in the Government Chemical Laboratory for moisture, protein, ash and water absorption.

TABLE 1.

Analytical data.

R.A.S. No.	Variety.	Flour Extraction.	Flour Ash.	Protein.		Water absorption.		Farinograph.		Fermentation Test.	
				Wheat.	Flour.	Farinograph.	Lapsley.	S.F.	D.W.	Time.	S.P.Q.
		per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	minutes.		minutes.	
1	Comeback	48·8	0·67	13·6	13·9	67·3	66·0	46·5	0	162	11·9
2	Do.	51·7	0·58	15·0	15·1	67·6	67·0	45·2	0	170	11·3
3	Do.	53·9	0·63	16·1	16·0	67·0	66·5	44·0	0	178	11·1
4	Do.	52·9	0·70	13·1	13·4	64·4	66·0	45·7	0	180	13·7
5	Do.	58·3	0·72	12·3	12·0	64·8	66·0	30·0	0	217	17·6
6	Do.	50·5	0·58	15·2	15·6	68·6	69·0	45·7	0	150	9·9
7	Do.	48·0	0·68	12·1	11·6	69·4	68·5	44·1	0	150	12·4
8	Do.	54·8	0·64	15·5	15·8	67·4	66·5	42·5	0	184	11·9
9	Do.	59·6	0·58	14·7	14·2	65·5	65·0	41·6	0	160	10·9
10	Do.	47·0	0·66	12·1	12·2	68·4	64·5	39·8	0	187	15·4
11	Do.	....	0·82	14·4	13·7	69·1	66·5	36·5	0	241	17·7
12	Bencubbin	....	....	12·1	....	....	....	....	....	39	3·2
13	Do.	....	....	12·0	....	....	....	....	....	54	4·5
14	Do.	....	....	12·8	....	....	....	....	....	40	3·1
15	Do.	....	....	12·7	..	..	..	..	..	44	3·5
16	Do.	....	....	10·2	....	....	....	....	....	33	3·2
17	Do.	....	....	11·7	....	....	....	....	....	46	3·9
18	Do.	50·5	0·74	11·5	10·0	60·6	55	7·8	60	46	4·0
19	Do.	....	....	12·6	....	....	....	....	....	60	4·8
20	Do.	....	....	11·3	....	....	....	....	....	60	5·3
21	Do.	....	....	11·4	....	....	....	....	....	36	3·2
22	Do.	....	....	10·6	....	....	....	....	....	43	4·1
23	Do.	....	....	9·5	....	....	....	....	....	32	3·4
24	Gluyas Early	....	....	13·6	....	....	....	....	....	36	2·6
25	Totadgin	....	....	13·0	..	..	..	..	..	32	2·5
26	Do.	....	....	15·4	....	....	....	....	....	34	2·2
27	Do.	54·4	0·64	12·2	11·0	64·1	54	5·3	110	33	2·7
28	Do.	....	....	14·7	....	....	....	....	....	43	2·9
29	Do.	....	....	12·1	....	....	....	....	....	49	4·0
30	Noongaar	....	....	11·7	....	....	....	....	....	39	3·3
31	Do.	....	....	11·1	....	....	....	....	....	27	2·4
32	Nabawa	....	....	12·8	....	....	....	....	....	60	4·7
33	Golden King	54·6	0·57	8·8	7·6	60·0	54·5	3·0	155	26	3·0
34	Merredin	....	....	10·3	....	....	....	....	....	57	5·5
35	Nabawa	51·9	0·74	11·8	11·1	61·1	54·5	7·1	70	39	3·3
36	Carrabin	....	....	13·6	....	....	....	....	....	64	4·7
37	Pusa IV.	46·9	0·71	14·6	14·6	71·6	66·5	41·0	0	124	8·5
38	Pusa	....	....	13·8	....	....	....	....	....	148	10·7
39	Nabawa	....	....	12·9	....	....	....	....	....	52	4·0
40	Merredin	....	....	9·9	....	....	....	....	....	47	4·7
41	Do.	....	....	7·8	....	....	....	....	....	28	3·6

42	Do.	51·9	0·57	11·3	10·2	59·2	55·0	6·5	100	55	4·9
43	Do.	....	....	12·4	....	....	....	....	....	84	6·8
44	Do.	....	....	15·1	....	....	....	....	....	52	3·4
45	Gluyas Early	51·6	0·64	11·2	8·3	62·6	54·0	4·3	115	34	3·0
46	Do.	....	....	12·6	....	....	....	....	....	34	2·7
47	Do.	....	....	14·0	....	....	....	....	....	52	3·7
48	Do.	....	....	12·7	....	....	....	....	....	44	3·5
49	Ford	58·7	0·73	9·5	10·0	54·4	56·0	6·5	80	116	12·2
50	Felix	50·0	0·66	11·6	10·5	61·2	55·5	9·25	32	50	4·3
51	Totadgin	....	....	8·8	....	....	....	....	....	27	3·1
52	Baroota Wonder	58·8	0·68	9·9	8·8	55·6	55·5	4·7	100	45	4·6
53	Flora	....	0·73	11·8	10·9	67·9	58·0	9·5	21	54	4·6
54	Gresley	58·1	0·67	9·9	8·8	57·8	56·0	5·5	47	52	5·2
55	Felix	44·2	0·66	9·2	8·0	57·9	55·5	5·3	75	48	5·2
56	Sutton	54·9	0·71	11·0	10·4	62·3	57·0	5·0	75	33	3·0
57	Ford	49·7	0·68	12·1	10·9	58·8	57·0	13·3	25	81	6·7
58	Totadgin	....	....	12·5	....	....	....	....	....	38	3·0
59	Pusa IV.	45·4	0·67	12·1	11·8	68·4	64·0	22·4	0	143	11·8
60	Carrabin	....	....	14·4	....	....	....	....	....	149	10·4
61	Do.	....	....	10·1	....	....	....	....	....	58	5·7
62	S.H.J.	....	....	9·9	....	....	....	....	....	67	6·8
63	Nabawa	42·4	0·63	10·7	9·4	60·5	56·0	8·9	45	54	5·0
64	Do.	....	....	8·5	....	....	....	....	....	30	3·5
65	Bencubbin	....	....	11·0	....	....	....	....	....	60	5·4

S.F. Farinograph strength figure. D.W. Farinograph dough weakening. S.P.Q. Specific protein quality.

The water absorption was determined by the method described by Lapsley (1924) in which the dough is mixed in a small hand-driven mechanical mixer, and the ability of the dough to stretch between the thumb and forefinger fully extended is taken as indicating the requisite consistency of the dough.

From general experience in the mill and in the bakehouse Western Australian wheats can be classified into two classes, (a) the Premium Strong White Wheats capable of carrying weaker wheats in a blend for bread flours; and (b) the Standard White Wheats which are in general slightly below the strength necessary for a satisfactory bread flour.

COMPARISON OF RESULTS.

The results of the analyses are shown in table 1, expressed on a 13.5 per cent. moisture basis. The flour extraction is calculated on the yield of total products, flour, bran and pollard, and not on the weight of wheat milled. The flour extractions are very low, ranging from 42 per cent. to 60 per cent. and the main factor governing extraction appears to be the speed of milling.

The ash contents are very high, varying from 0.57 per cent. to 0.82 per cent. despite the low flour extraction used.

For seven of the flours the protein content of the flour is higher than that of the wheat and this must be ascribed to sampling errors as separate samples for the two tests were drawn from about a bushel of wheat.

From the data in table 1 a large number of comparisons can be made and these have been done graphically, by plotting each factor against each of the others except that, because there is a very good negative correlation between the farinograph strength figure and the dough weakening, only the comparison of the strength figure with the other factors is discussed here. Similarly there is a very good direct relation between the protein content of the wheat and of the flour derived from it, so that the comparison of only one of these two factors with the other data need be considered here.

Specimen graphs are shown in figs. 2-9.

1. *Flour extraction and flour ash.*

There is no relationship between the extraction and the ash content of the flour for these 28 flours from the Brabender experimental mill.

2. *Flour protein content and wheat protein content.*

As is to be expected there is a good correlation between the protein content of the wheat and of the flour derived from it. There are two anomalies, No. 45 Gluyas Early in which the flour protein is much lower than would be expected and No. 49 Ford in which the flour protein is much higher than would be expected. The average flour protein content is 0.7 per cent. less than the average wheat protein content.

3. *Flour (or wheat) protein content and water absorption.*

(a) Farinograph water absorption.

There is a broad direct relationship between flour (or wheat) protein content and farinograph water absorption enabling an estimate of protein content to within about 1 per cent. to be made from the water absorption. A closer relationship than is found here for individual varieties would be expected for commercial flours milled from a number of varieties.

(b) Water absorption by the method of Lapsley.

The graph of flour protein against Lapsley water absorption separates into two groups of points, group (a) containing the Premium Strong White varieties, and group (b) containing the Standard White varieties.

Group (a) has higher water absorption and strength figures than has group (b) and within each group there is a slight direct relation between protein content and water absorption.

4. *Flour (or wheat) protein content and strength figure.*

The graph of these two factors separates into two groups of points—

(a) containing the Premium Strong White varieties which have the higher strength figures and protein contents. Within this group there is practically no relation between protein content and strength figure.

(b) containing the Standard White varieties. Within this group there is a direct relation between protein content and strength figure which appears to be less marked the higher the protein content.

5. *Wheat protein and fermentation time.*

The points on this graph segregated into two groups by fermentation time, but not by protein content; group (a) containing the Premium Strong White varieties had much longer times, but not necessarily higher protein contents, than did group (b) containing the Standard White varieties.

There is no evidence of a relationship between the two factors either between the two groups or within either group. The sample of "Ford" is anomalous in having a long fermentation time and a low protein content.

6. *Wheat protein and specific protein quality.*

Since there is a good direct relationship between the fermentation time and specific protein quality as will be shown later, the graph of wheat protein against specific protein quality is very similar to that of wheat protein against fermentation time. There is the same segregation into two groups, the same lack of correlation and the variety "Ford" occupies a similar anomalous position.

7. *Water absorption as measured by the Farinograph and by the method of Lapsley* (1924).

The graph of these two factors is again divided into the same two groups of points. Within the Premium Strong White group there is no relationship between the two methods of determining water absorption, and within the group containing the Standard White varieties there is perhaps a slight inverse relationship between the two methods.

For 24 of the 28 flours the water absorption as determined by the Farinograph is higher than that determined by the method of Lapsley, and for the 28 flours the average Farinograph water absorption is the higher by 3.1 per cent.

Neither of these two methods has been compared with local bakehouse absorption for any extensive range of water absorptions so that it is not yet possible to decide which of the two methods yields results more comparable with bakehouse practice.

The Farinograph appears to be the more sensitive of the two methods as it has the larger range in water absorption for the flours investigated.

8. *Farinograph water absorption and strength figure.*

The graph of these two factors again segregated into the same two groups of points, group (a) containing the Premium Strong White wheats having higher strength figures and water absorptions than group (b) containing the Standard White varieties. Within group (a) there is no relationship between these two factors, but within group (b) there is a slight direct relationship. The variety "Ford" is anomalous in having a much lower absorption than was indicated by its strength figure.

9. *Farinograph water absorption and fermentation time.*

The points on this graph again formed two groups, group (a) containing the Premium Strong White wheats having higher water absorptions and fermentation times than group (b) containing the Standard White varieties. The variety "Flora" is anomalous in that it has a water absorption comparable with group (a), but a fermentation time comparable with group (b). Within each group there is evidence of an inverse relationship between the two factors. Since the fermentation time test was done with a fixed water absorption the inverse relationship found may in part be the reflection of the effect of the consistency of the doughball on the fermentation time.

10. *Farinograph water absorption and specific protein quality.*

The points on this graph again separated into two groups, group (a) containing the Premium Strong White wheats having higher water absorptions and specific protein quality than group (b) containing the Standard White wheats. The variety "Flora" again occupied an anomalous position with a water absorption comparable with group (a), but specific protein quality comparable with group (b).

Within group (a) there was no evidence of a relationship between the two factors but within group (b) there was an inverse relationship, the lower the specific protein quality the higher the water absorption.

11. *Lapsley water absorption and strength figure.*

The graph of these two factors is again divisible into the same two groups of points, group (a) containing the Premium Strong White wheats having higher strength figures and water absorptions than group (b) containing the Standard White wheats. Within group (a) there is no relationship between the two factors, but within group (b) there is a direct, but not close relationship, the higher the strength figure the higher the water absorption.

12. *Lapsley water absorption and fermentation time.*

The points on this graph again separate into the same two groups, group (a) containing the Premium Strong White wheats having higher water absorptions and fermentation times than group (b) containing the Standard White varieties. Within group (a) there is no relationship between the two factors, but within group (b) there is a direct relation between them, the greater the fermentation time the higher the water absorption.

The variety "Ford" occupies an anomalous position in that its fermentation time approaches that of group (a), but its water absorption is that of group (b).

13. *Lapsley water absorption and specific protein quality.*

The graph of these two factors is very similar to the previous graph as is to be expected from the good relationship between "time" and specific protein

quality. There is the same separation into two groups, the same absence of relationship in group (a) and the same direct relationship in group (b) with the variety "Ford" in a similar anomalous position.

14. *Farinograph strength figure and dough weakening.*

There is a very good inverse relationship between these two factors as it is to be expected that the sooner the top of the graph falls below the maximum consistency (the lower the strength figure) the greater the fall at the end of 10 min. mixing (the greater the dough weakening).

The relationship is not linear and is clouded by the fact that every flour with a strength figure of more than about 12 had necessarily a dough weakening of zero.

15. *Strength figure and fermentation time.*

The points on this graph again separated into the same two groups, group (a) containing the Premium Strong White wheats having higher strength figures and fermentation times than group (b) containing the Standard White wheats.

The sample of "Ford" was anomalous, its "time" approaching that of group (a) but its strength figure being that of group (b).

Within group (a) there is evidence of an inverse relationship between the two factors, but within group (b) there is a good, direct, linear relationship between the two factors.

16. *Strength figure and specific protein quality.*

This graph was very similar to the previous one as is to be expected from the good relationship between fermentation time and specific protein quality. There is the same segregation into two groups, the same anomalous position of "Ford" and within group (a) the same slight inverse relationship. Within group (b) the direct linear relationship is not as good as in the previous graph.

17. *Fermentation time and specific protein quality.*

There is a good direct linear relationship between these two factors as has been noted several times in this laboratory (unpublished data). This good relationship appears to be a mathematical necessity because of the relatively small range in protein content (7.8 per cent to 16.1 per cent.) as compared with the range in fermentation time (27 min. to 241 min.) and in specific protein quality (from 2.1 to 16.9 mins. per g. of protein).

DISCUSSION.

From the data obtained from the two tests, the wholemeal fermentation time test and Farinograph, it is clear that for the wheats examined water absorption, either by the Farinograph or by the method of Lapsley, the strength figure, the dough weakening, the fermentation time or the specific protein quality satisfactorily segregate the Premium Strong varieties Comeback, Pusa IV., S.H.J. and Carrabin from the Standard White varieties. However, the varieties are anomalous in that they are not placed in the same order by each of the above factors.

For the Premium Strong White wheats there is a direct relationship between the protein in the wheat and in the flour derived from it, between the water absorption from the Farinograph or by the method of Lapsley and the flour protein, and between the fermentation time or strength figure and the specific protein quality. There is a slight inverse relationship between the Farinograph water absorption, or strength figure and the fermentation time.

For the Standard White wheats there is a direct relationship between the protein in the wheat and in the flour derived from it, between the Farinograph water absorption and the flour protein, between the fermentation time or strength figure and the specific protein quality and between the fermentation time and the strength figure. There is a slight direct relationship between the flour protein, Farinograph or Lapsley water absorption and strength figure, and between the Lapsley water absorption and flour protein, fermentation time or specific protein quality. There is a good inverse relationship between the strength figure and the dough weakening and a slight inverse relationship between the Farinograph water absorption and the fermentation time or specific protein quality.

There is no relationship between the flour extraction and the flour ash content for the Brabender experimental mill, nor between the protein content of the wheat and fermentation time or specific protein quality nor between the water absorption as determined by the Farinograph and by the method of Lapsley.

Thus the fermentation time and the Farinograph strength figure measure substantially the same factor and each confirms the other as a measure of the baking quality of the flour. Both of these factors are affected by the amount and the quality of the protein content. For very strong wheats or flours, however, the differences between the results by either test are not significant. The few results available indicate that if the fermentation time is greater than 150 mins. or if the strength figure is greater than 24 mins. differences in quality are not significant.

Thus for Western Australian varieties of wheat it appears that either fermentation time or Farinograph strength figure can be used for classification with respect to baking quality. The confirmation of the fermentation time test by the Farinograph is of considerable importance in view of the usefulness of the "time" test in the early stages of wheat breeding.

SUMMARY.

The entries for the Wheat Section of the Royal Agricultural Show, 1937, consisting of 65 samples representing 17 varieties were examined by the wholemeal fermentation time test. Of these, 28 samples, representing 14 varieties, were milled experimentally and the flours analysed and tested in the Farinograph. From the data obtained the wholemeal fermentation time and the Farinograph strength figure measure substantially the same factor in flour quality, but neither factor differentiates satisfactorily between very strong wheats or flours.

The Farinograph water absorption and the protein content of the flour are sufficiently closely related to enable an estimate of the one to be made from a knowledge of the other.

ACKNOWLEDGMENTS.

The writer is indebted to the Government Chemical Laboratory for the determination of the wholemeal fermentation time and for the analyses of the wheats and flours.

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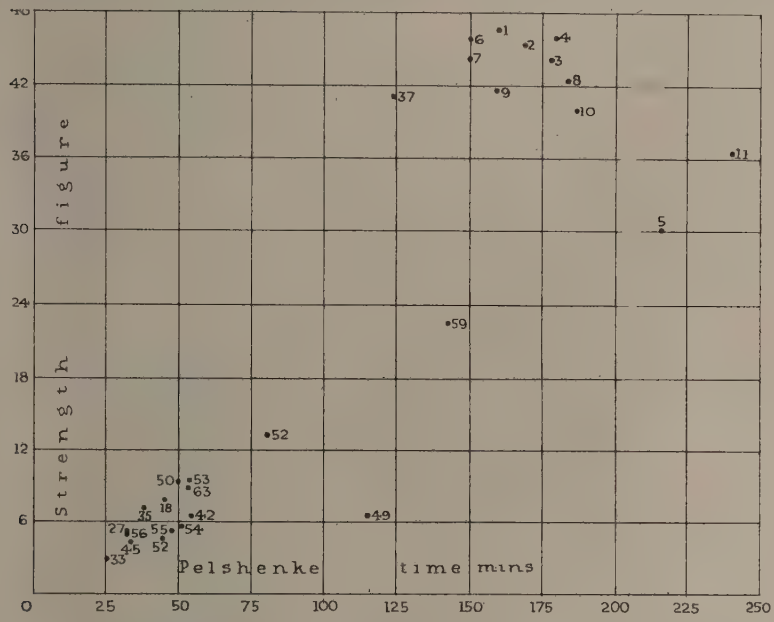

Fig. 2.—Scatter diagram of Pelshenke time and strength figure.

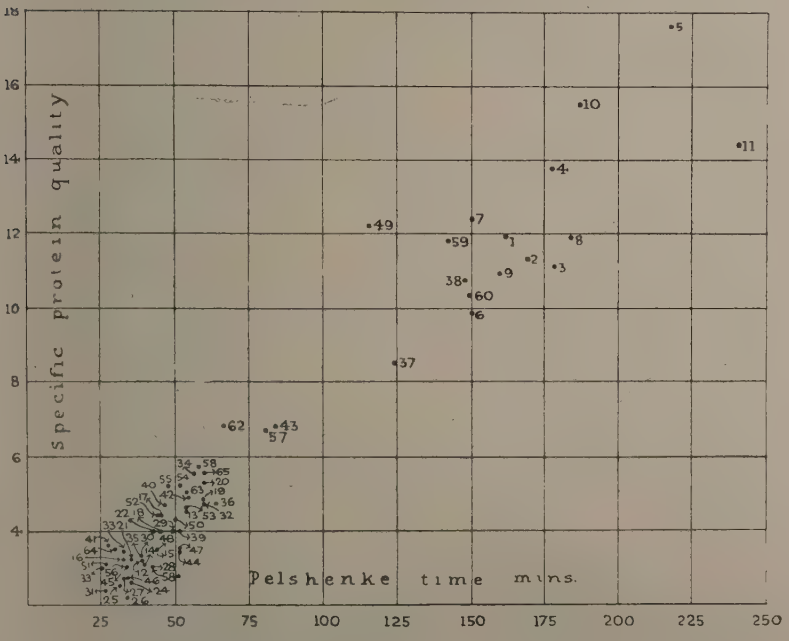

Fig. 3.—Scatter diagram of Pelshenke time and specific protein quality.

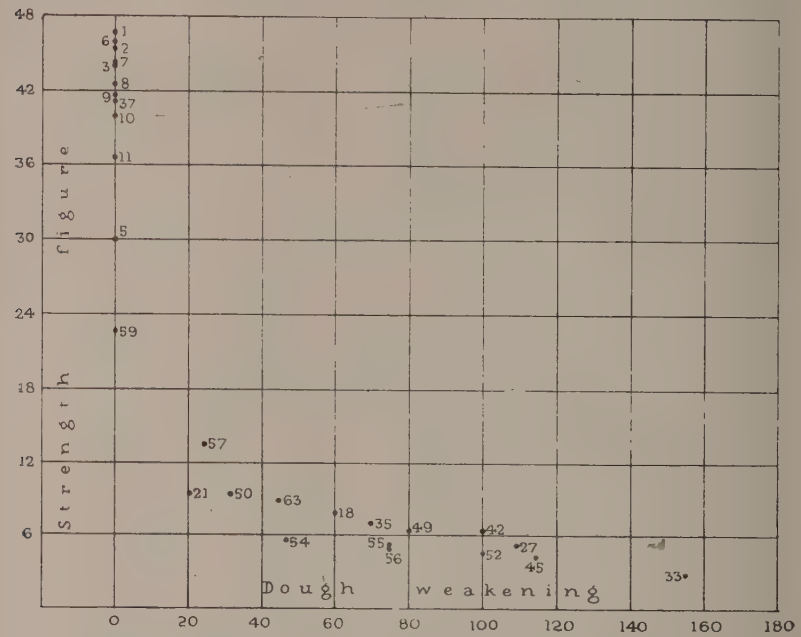

Fig. 4.—Scatter diagram of dough weakening and strength figure.

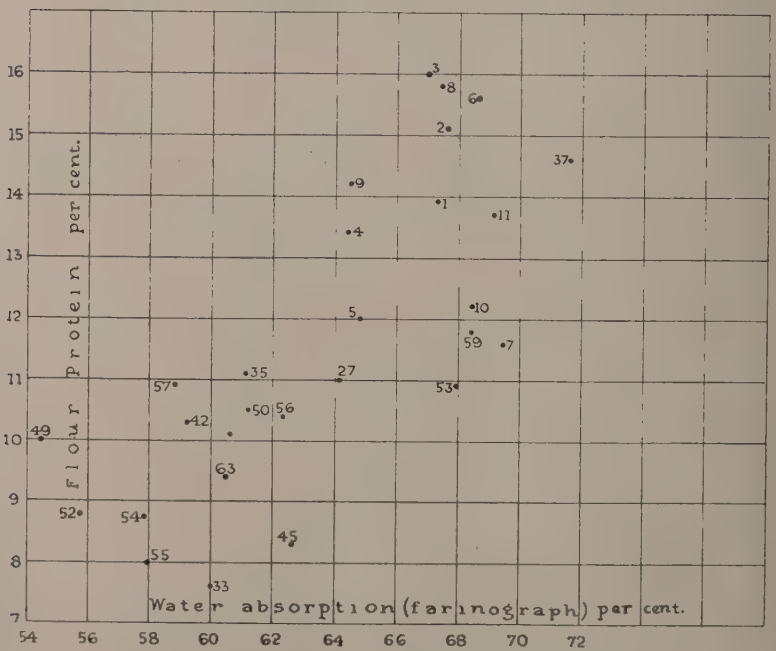

Fig. 5.—Scatter diagram of water absorption and flour protein.

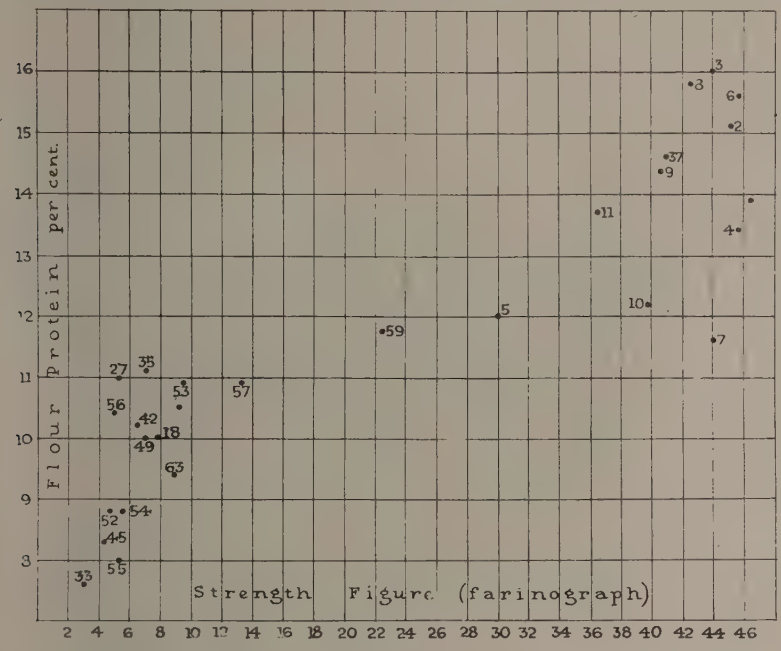

Fig. 6.—Scatter diagram of strength figure and flour protein.

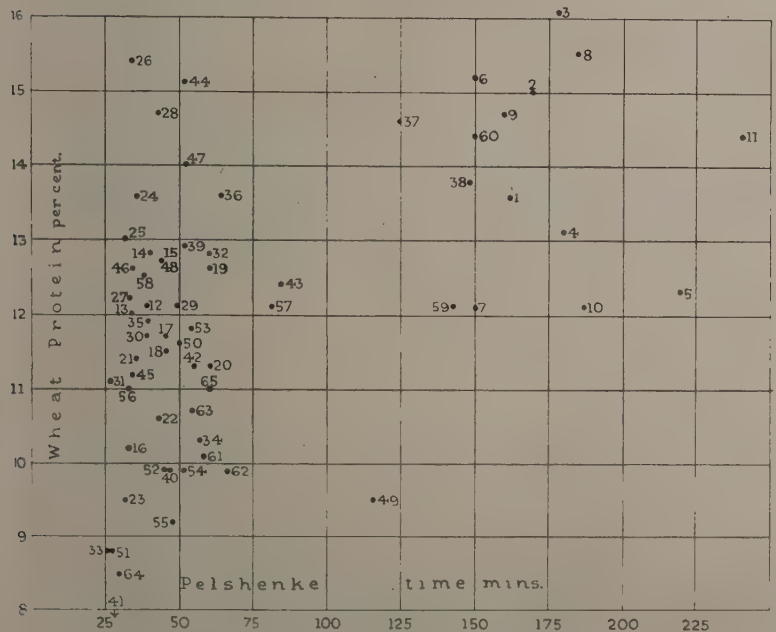

Fig. 7.—Scatter diagram of Pelshenke time and wheat protein.

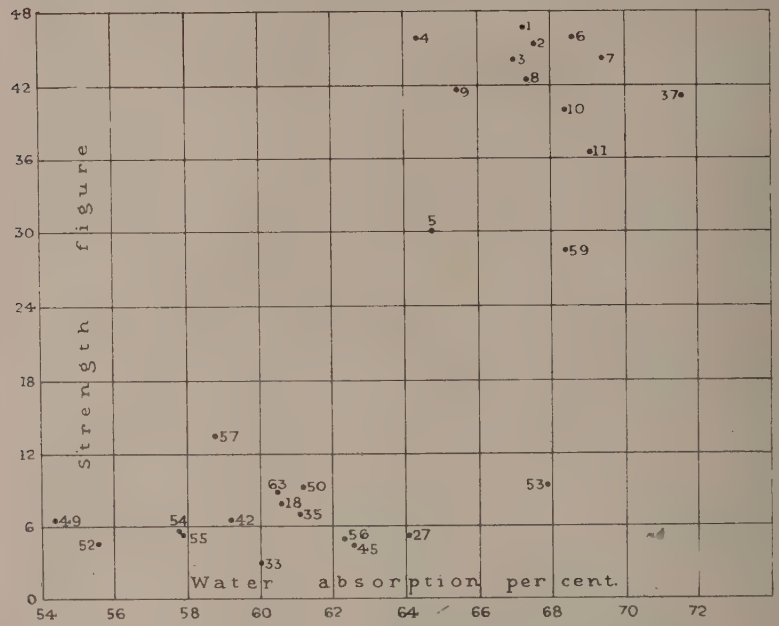

Fig. 8.—Scatter diagram of water absorption and strength figure.

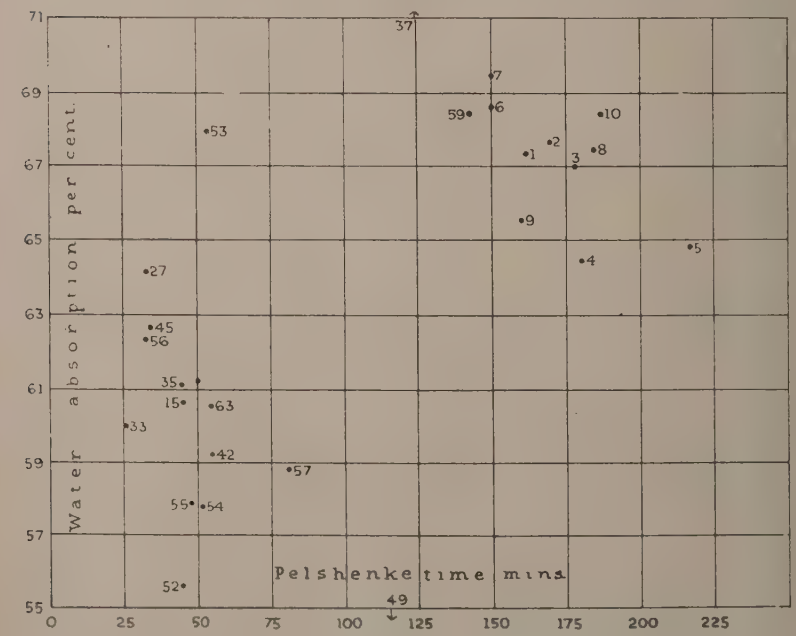

Fig. 9.—Scatter diagram of Pelshenke time and water absorption.

LEAF RUST OF STONE FRUITS.

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Leaf rust of stone fruits does not usually reach epidemic proportions in Western Australia until fairly late in the autumn. Its main effect is always to cause a premature dropping of the leaves. Towards the end of the season it may become so abundant on the great majority of the leaves of peach, nectarine, almond and plum trees, that the trees may be rendered prematurely dormant. This does not usually occur sufficiently early in the season, however, in commercial orchards, to cause serious under-development in the buds which are to produce the flowers and growth of the following spring, although it may do so under the usually more humid conditions of the backyard orchard. Normally, the disease is not well in evidence until the fruit has been gathered and the buds are well advanced towards maturity.

In the case of some varieties of peaches which ripen very late in the season, the fruits may become attacked and may show small broken blisters from which are liberated the innumerable spores, or seed-structures, of the fungus responsible for the disease. The "Goldmine" nectarine is frequently very seriously attacked on the leaves and also the fruits, especially in the wetter parts of the State, as for example in the Manjimup-Pemberton and other extreme south-western districts. Seedling peaches appear to be more highly susceptible to the disease, as a general rule, than named commercial varieties. Plums are generally less seriously affected in this State than peaches, nectarines and almonds.

In most seasons rust is first noticed about January, thereafter becoming steadily more abundant until the end of autumn. Until recently it has not usually been regarded as a very important disease in this State, but it came very prominently under notice during the past summer and early autumn, being greatly

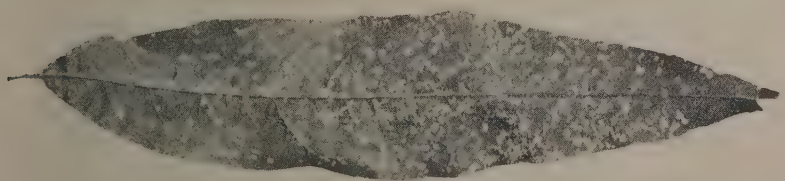

Fig. 1.

Upper surface of Peach Leaf showing yellow spotting due to Rust.

(*Photo N.S.W. Dept. Agric.*)

favoured by the comparatively low temperatures, frequent overcast skies and rather humid weather, with a marked absence of hot, dry easterlies—all of which have been marked features of the fruit season now drawing to a close.

Affected leaves may be recognised by the occurrence of more or less numerous, generally rather angular and straightsided, yellow spots on the upper surface, which contrast quite markedly with the bright green of the still healthy tissues. (Fig. 1.) On the underside, and corresponding with these yellow spots, pustules are developed, which burst and expose dusty masses of minute rust-coloured spores.

(Fig. 2.) The spores (fungal seed-bodies) are the means by which the causal fungus (*Puccinia pruni-spinosae,* Pers.) is blown by the wind, or splashed by rain, or water from sprinklers, from leaf to leaf, or tree to tree, each being a potential source of infection. Two types of spores are produced, known respectively as *uredospores* and *teleutospores*, the former being single-celled and the latter two-celled. Both types are covered with minute spines, whence derives the latter part of the species name of the parasite.

FIG. 2.

Under surface of Peach Leaf showing Rust pustules.

(*Photo N.S.W. Dept. Agric.*)

The lower and older leaves first show signs of the disease, turn yellow and fall prematurely, leaving the upper and younger leaves at the ends of the branches. Peach and nectarine fruits attacked by rust become rough and scabby or spotted with small broken blisters.

The *uredospores* disseminate the fungus rapidly in the summer and autumn, and in warm climate regions serve also to carry the disease over from one autumn to the following spring or summer, but in cold countries, such as England, the *teleutospore* stage brings about infection of species of *Anemone, Hepatica* and *Thalictrum,* and it is necessary for reinfection of stone fruits to take place each year, during the growing period, from spores known as *aecidiospores,* which are produced by the infected alternate host. This stage has not been recorded on any of the alternate hosts in this State.

CONTROL.

1. In the late autumn, shortly before the time when the trees normally drop their leaves, spray with home-made Bordeaux mixture 6-4-40 strength, plus ½ lb. Calcium caseinate spray spreader to each 40 gallons of spray. This spray will probably cause the leaves to fall away shortly after spraying, as stone fruit trees, other than apricots, are very sensitive to Bordeaux mixture at any time when the leaves are present. No harm, however, will result to the trees from Bordeaux mixture applied at this time of the year. Information concerning the preparation of home-made Bordeaux mixture will be found in Leaflet No. 314, obtainable free of charge on application, or in pages 410-427 of this Journal for December, 1935.

2. All prunings should be burnt promptly, so as to destroy, as far as possible, the sources of infection for the following season.

3. In the early spring, about a fortnight before any signs of sap movement in the trees may be expected, plough under the green manure crop, together with any fallen fruit tree leaves, then digging-under those parts of the ground which cannot be ploughed, so as to bury the spores with which the leaves and upper regions of the soil may be contaminated. Any subsequent workings of the ground

should be delayed as long as possible, and be as shallow as satisfactory, so as to avoid bringing the leaves and spores to the surface again.

4. In the early pink-bud stage, spray again with 6-4-40 home-made Bordeaux mixture plus ½ lb. Calcium caseinate spray spreader. Further sprayings may not be necessary, but if experience proves them to be required, under the local climatic and other conditions obtaining in the orchard of the grower concerned, they should be as follows:—

5. At the "shuck-fall" stage, spray with liquid lime sulphur 1 part by volume to 100 parts by volume of water, plus ½ lb. calcium caseinate spray spreader to every 50 gallons of spray, or spray with "dry mix sulphur lime," made up as indicated below.

6. 10 days later, dry mix sulphur lime.

7. 2 weeks later than No. 6, dry mix sulphur lime.

8. 3-4 weeks before ripening, dry mix sulphur lime.

Formula for Dry Mix Sulphur Lime.

Sulphur (Commercial Flowers)	8 lbs.
Hydrated lime (finely ground finishing lime)	4 lbs.
Calcium caseinate	½ lb.
or	
Powdered skim milk	½ lb.
Water	50 gallons

The spray outfit is partly filled with water, say one-quarter filled. The ingredients are mixed dry in a tub or barrel and then washed slowly through a fine-mesh wire screen by the force of the water with which the spraying outfit is being filled, the agitator being kept working continuously. Thorough agitation is necessary when using dry mix sulphur lime.

If it is found impracticable to purchase finely ground hydrated lime as such, approximately the right quantity can be prepared by taking 4 lbs. best quality, specially-selected, freshly-burnt spraying lime and carefully slaking it with water in the usual way. When thoroughly slaked, allow to cool somewhat, and then wash through a fine-mesh wire screen into the spray outfit, which has already been about one-quarter filled with water. Keep the agitator going, then wash the other ingredients through the screen and bring up the volume to the correct level before commencing to spray. Four gallons of lime which has been slaked in water at the rate of one pound to the gallon of water, as recommended for the preparation of Bordeaux mixture by the method of stock solutions, may be measured out after thorough stirring, instead of weighing out 4 lbs. of quick lime. (See Leaflet 314 or this Journal, December, 1935, pp. 410-427.)

9. To lessen the ravages of leaf rust on peaches, nectarines, almonds or plums, these should always be grown, in backyard gardens (or elsewhere), in a very sunny situation, and while it may be necessary to apply water at various times during the summer and autumn months, this should be applied in large quantities occasionally, rather than "a little and often," and every effort should be made to keep the humidity of the air in the neighbourhood of the trees as low as possible. Wetting of the foliage by means of a sprinkler is especially to be deplored.

EGG-LAYING TRIALS.

MURESK AGRICULTURAL COLLEGE.

G. D. SHAW,
Poultry Adviser.

The trial just concluded is the second under the new series. This series started on 1st April, 1936. The duration of the trial is for 48 weeks ending on the 2nd of March each year, and there is a break of four weeks between the end of one trial and the beginning of the next. This is to allow for the thorough cleaning of the pens in readiness for the reception of the new birds If at the end of the 48 weeks it is considered that pens of birds may break an existing 12-months record, those pens of birds are retained for the full period of 12 months.

Two hundred and forty birds entered for the trial. All birds are weighed at the beginning of the trial and during the laying period they are checked weighed in order to study the condition. On despatch to the owners at the end of the trial all birds are again weighed.

The management of the trial is in the hands of a committee which consists of the Principal of the College, Mr. H. J. Hughes (Chairman), the Poultry Adviser of the Department of Agriculture, Mr. G. D. Shaw, Mr. S. Dolman, Cranleigh Poultry Farm, and Mr. F. Landquist of York, the two latter gentlemen being the representatives of the competitors. The Committee of Management meet at the College once a month and direct the policy of the trial.

There are 360 pens available and all birds are tested individually, all eggs being weighed daily and the scales used are tested and graduated to one-tenth of an ounce. The College is situated some 60 miles from Perth. The soil is ideal and the conditions good. Heat in summer has at times caused distress, but this factor is now held in check by the growth of lilacs which are in between the rows of the laying pens. The pens are in rows of 84 with a break in the centre of the row.

The conditions governing the trial are as follow:—

COMMITTEE OF MANAGEMENT.

The Committee of Management shall consist of the Principal of the College, the Poultry Adviser, Department of Agriculture, or officers acting in their stead, and two representatives elected by the breeders taking part in the preceding trial.

Note.—The term "breeder" is given to those who have entered birds in the trials.

POWERS OF THE COMMITTEE.

The Committee shall have absolute control of the trials conducted during its tenure of office.

It shall recommend what tests are to be carried out and arrange the conditions and regulations governing the same.

The representatives elected shall take office on 1st April succeeding the date of appointment.

The committee shall meet at such times as it may deem necessary.

The trial shall consist of the following sections:—

Section "A"—Pen of Six Birds—All Light Breeds.
Section "B"—Pen of Six Birds—All Heavy Breeds.
Section "C"—Pen of Six Birds—All Medium Heavy Breeds.

The trial shall extend from 1st April until 2nd March (48 weeks). The leading group or individual bird in each section may be allowed to remain at the College for the full period of twelve months.

Each breeder shall be charged an entrance fee of 5s. per bird, 2s. 6d. per bird to accompany application for pens. The balance of 2s. 6d. per bird is to be forwarded to the Principal, Muresk Agricultural College, within 14 days after notice of allotment of pens; otherwise pens may be allotted to other applicants and the 2s. 6d. application fee forfeited.

For any of the above sections pure-bred birds only must be entered.

All eggs shall be the property of the Muresk Agricultural College.

Each of the pullets will be single tested, housed (semi-intensive), and the individual numbers and weight of eggs will be kept.

REGULATIONS.

1. In each section the trial will be decided by the highest number of first-grade eggs obtained by each group of birds and by each individual bird in their respective sections.

2. Sections "A," "B" and "C."—During the first two months of the trial a first-grade egg shall weigh not less than $1\frac{3}{4}$ ozs., thereafter during the remainder of the trial a first-grade egg shall weigh not less than 2 ozs.

Second Grade.—The minimum weight of a second-grade egg shall be not more than $\frac{1}{4}$ oz. less than a first-grade egg. Second-grade eggs will be recorded but not counted.

3. Eggs under $1\frac{1}{2}$ ozs. in weight during the first two months of the trial and under $1\frac{3}{4}$ ozs. in weight during the remainder of the trial, soft-shelled, or broken will be recorded, but not counted in trial results.

4. In all sections the actual weight of each egg shall be kept.

Note.—The certificate for the winter test, 1st April to 31st July, shall be given subject to Rules 2 and 3.

5. Progress results will be published weekly as far as practicable, and all prizes shall be awarded as soon as possible after the termination of the trial. Results to be reported under breed headings.

6. No protest shall be considered unless received within 14 days of the alleged breach of regulations, and accompanied by a deposit of £1, which deposit shall be returned if the protest is upheld, or forfeited if, after inquiry, the protest is considered to be frivolous or without foundation.

7. Records shall be kept of the average cost per head of food consumed.

8. All birds to be accepted must conform to the following conditions:—

(a) Shall be the property of the breeder.

(b) Must be not less than six months and not more than nine months of age on 1st April.

(c) Must be fair specimens of the breed.

(d) Must weigh not less than—

Section "A"—Light Breeds—	lbs.
Leghorn, Ancona	$3\frac{3}{4}$
Minorca	4

Section "B"—Heavy Breeds—	
Australorp	5
Sussex, Langshan	5
Plymouth Rock	5
Section "C"—Medium Heavy Breeds—	
Barnevelder	5
Rhode Island Red	5
Wellsummer	4½
Wyandotte	4½

9. All birds sent to the trial must conform with the weight prescribed in the preceding paragraph, otherwise the committee shall cancel the allotment pens, in addition to which the entrance fee may be forfeited.

10. All birds shall be treated for vermin and delivered at the Muresk Agricultural College, Muresk, between 27th March and 31st March, inclusive, in new coops or crates, with the breeder's name and address clearly stencilled or painted thereon. Entries will not be accepted from any person whose premises are tick-infested or whose flock is suffering from any infectious or contagious disease.

11. Freight to the College is to be prepaid or delivery will not be accepted. Freight on rejected birds must be paid by the breeder.

12. All birds must be ringed with the numbered leg bands supplied and forwarded free to the breeder. These will correspond with the number of the pens allotted.

The pens having overhead netting, it is unnecessary to cut any bird's wing feathers.

13. The Poultry Adviser, or his representative, shall have the power to reject any bird which in his opinion is not of the correct age, or which he considers does not conform in any way to rule 9, and his decision shall be final.

14. Any bird found to be suffering from an infectious or contagious disease, or with crooked breasts, or side sprigs in combs will be rejected and returned, and shall be replaced by a suitable one within seven days after the notification of same. If any bird is found infested with tick the group will be rejected, the entry cancelled, and the entry fee forfeited.

15. In the event of a bird during the course of the trial becoming diseased, incapacitated from laying, or developing vicious habits (such as egg-eating or feather-eating) it may be returned, or, on the written authority of the owner, destroyed.

Should this occur, the breeder may replace it with another bird of the same age and breed; in the case of a bird dying, replacement may be made. Any score standing to the credit of a bird which is replaced shall be struck out.

16. No breeder shall withdraw any bird until the termination of the trial, except as provided in rule 15.

17. The committee reserves to itself the right to inspect or to have inspected any applicant's stock with a view to determining whether the quality and character of the birds warrant the allotment of pens.

18. (a) Any breeder taking part in the current trial will have the right of allotment of one pen of six birds per section in the succeeding trial. After such allotment new applications will have the right of allotment of one pen of six birds per section. Should there then be any vacant pens they will be allotted by ballot to any applicant.

(b) If after the allotment of pens it is ascertained that incorrect information has been furnished the allotment may be cancelled and the birds returned. In such case the entrance fee shall be forfeited and the applicant may be debarred from entry to any future trial.

19. Any breeder violating or failing to conform to these regulations shall be subject to such disqualification as the committee may decide.

20. Where there is a tie for any place, the award shall be given to the breeder whose bird or group (as the case may be) lays the greater total weight of first-grade eggs.

21. While every care will be taken, the committee will not be responsible for loss or injury to any birds in any way in connection with the trial.

22. The committee may disqualify any breeder and may refuse entry to subsequent trials where such breeder publishes in any way statements of records not in accordance with the official records of the trials.

23. The committee's decision in all matters shall be final.

PRIZES.

Note.

Certificates will accompany all prizes.

No prizes shall be awarded in any section unless there are at least three entries. No second prize will be awarded unless there are at least four entries.

CHAMPION CERTIFICATE.

A champion certificate will be awarded to the group pen from sections "A" and "B" and "C" obtaining the highest total of first-grade eggs during the term of the trial.

GOVERNMENT STANDARD CERTIFICATE.

A Government standard certificate and a registered sealed copper ring will be awarded to all birds laying not less than 200 first-grade eggs or over during the term of the trial.

DISCUSSION.

Some explanation with reference to the classes may not be out of place. In the schedule it will be noticed that light, heavy, and medium-heavy classes are defined by weight. This is not a clear interpretation of the classes. It has been found that the activity of the different breeds vary, so much so that the feeding of light birds must be on a different plane to the feed given to the heavy. It was found that the food giving the best results for light breeds was too fattening for the heavy breeds. This was because the heavy breeds were not as active as the light and therefore did not utilise the carbohydrates to the best advantage. Hence the heavy breeds are fed on a narrower ration than are the light breeds.

Again, the breeds placed into what is described as medium-heavy are not necessarily lighter in weight than are the heavy breeds, but those placed in the medium-heavy class are more active than those breeds placed in the heavy class, yet not as active as those of the light breeds quoted. Hence the rations suitable for the medium-heavy breeds should be wider than that given for the heavy breeds but narrower than that given to the light breeds. This has been satisfactory and

the feeding at the laying trial is based on the article on "Feeding" published in the *Journal of Agriculture,* September, 1934, pages 435 onwards, and in the December, 1936, *Journal,* pages 465 onwards. This system of feeding had allowed the birds the necessary requirements of protein and carbohydrates consistent with their activities and the noticeable factor at the completion of each trial of the second series has been that the birds have been returned to their owners in good condition, each bird having put on weight during the period, but no bird has carried superfluous fat.

Australorps again proved their superiority over the White Leghorns. There is need for alarm at such a result, but the breeders are alive to the shortcomings and the trial for 1938-39 should show a marked improvement in production.

The following are the results at the completion of the trial on 2nd March, 1938:—

SUMMARY.

Teams of Six Birds.

Section "A"—Light Breeds—Westralian Farmers' Cup and Replica—
E. E. Price. Score—First-grade, 1,257. Second-grade, 30.

Section "B"—Heavy Breeds—W.A. Produce Auctioneers' Cup and Replica—
M. H. Dadley. Score—First-grade, 1,488. Second-grade, 54.

Section "C"—Medium-Heavy Breeds—Ian Hazlett Cup and Replica—
R. Harrison. Score—First-grade, 1,172. Second-grade, 15.

Teams Entered by Returned Soldiers—

Light Breeds—R.S.L. Trophy—
Webb's Hatchery. Score—First-grade, 1,099. Second-grade, 151.

Heavy Breeds—R.S.L. Trophy—
M. H. Dadley. Score—First-grade, 1,488. Second-grade, 54.

Medium-Heavy Breeds—R.S.L. Trophy—
R. Harrison. Score—First-grade, 1,172. Second-grade, 15.

Winter Test (*Teams of Six Birds*—1*st April to* 31*st July*).

Section "A"—Light Breeds—Western Ice Trophy—
H. P. Chalmer. Score—First-grade, 415. Second-grade, 11.

Section "B"—Heavy Breeds—Western Ice Trophy—
M. H. Dadley. Score—First-grade, 535. Second-grade, 2.

Section "C"—Medium-Heavy Breeds—Western Ice Trophy—
R. Harrison. Score—First-grade, 485. Second-grade, nil.

Highest Score First-Grade Eggs.

Light Breeds—

First Prize—McFarlane Cup and Replica—
H. P. Chalmer, Bird No. 4. Score—First-grade, 243. Second-grade, 2.

Second Prize—James Goss Trophy—
Webb's Hatchery, Bird No. 78. Score—First-grade, 240. Second-grade, 21.

Heavy Breeds—

First Prize—Bairds Cup and Replica—

W. & E. Kerr, Bird No. 167. Score—First-grade, 267. Second-grade, 1.

Second Prize—Barrow Linton Trophy—

*M. H. Dadley, Bird No. 57. Score—First-grade, 265. Second-grade, 0.

Medium-Heavy Breeds—

First Prize—Enston Cup and Replica—

Cranleigh Poultry Farm, Bird No. 104. Score—First-grade, 211. Second-grade, 31.

Second Prize—Harrold & Murray Trophy—

†R. Harrison, Bird No. 114. Score—First-grade, 206. Second-grade, 1.

First Bird to Lay 200 First-Grade Eggs.

Light Breeds—T. Newby Trophy—

Webb's Hatchery, Bird No. 78, on December 21st, 1937.

Heavy Breeds—Bateman Trophy—

M. H. Dadley, Bird No. 60, on November 16th, 1937.

Medium-Heavy Breeds—Spearwood Branch P.P.A. Trophy—

Cranleigh Poultry Farm, Bird No. 104, on January 25th, 1937.

DETAILED RESULTS.

SECTION "A" (LIGHT BREEDS)—TEAMS OF SIX BIRDS.

Name of Competitor and Birds Nos.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	Totals 1st.	Totals 2nd.
H. P. Chalmers— 1—6	147	37	224	1	141	3	243	2	189	1	208	33	1152	77
E. E. Price— 7—12	196	....	200	28	221	....	182	2	222	....	236	....	1257	30
Thorpe P.F.— 13—18	40	172	28	129	128	28	201	3	108	128	148	44	653	504
F. B. Vickers— 19—24	213	4	173	4	216	5	195	7	78	52	37	164	912	236
Mrs. M. H. Dadley— 25—30	127	4	220	1	111	19	194	1	234	5	166	1	1052	31
M. H. Dadley— 31—36	192	2	141	1	199	12	152	37	180	27	228	....	1092	79
R. Harrison— 37—42	158	4	230	2	169	1	204	21	155	29	179	9	1095	66
J. Duncan— 43—48	190	7	216	....	171	4	174	1	177	....	167	4	1095	16
N. & V. Trimble— 49—54	115	42	194	17	178	2	92	74	169	27	174	42	922	204
R. Lowe— 55—60	172	9	143	3	190	30	153	22	176	1	173	13	1007	78
Mrs. R. Lowe— 61—66	162	11	133	39	133	27	207	19	138	....	158	13	931	109
E. Singleton— 67—72	135	....	174	6	182	57	168	74	172	27	135	1	966	165
Webb's Hatchery— 73—78	229	13	171	41	192	19	118	5	149	52	240	21	1099	151
Cranleigh P.F.— 79—84	159	74	99	5	59	105	139	50	151	23	122	53	729	310
Runnymede P.F.— 127—132	109	81	45	158	193	8	26	170	189	56	176	32	738	505
C. C. Lewis— 133—138	194	45	69	178	136	53	121	43	192	17	129	52	841	388

* M. H. Dadley—Bird No. 57: Score 1st Grade 265; 2nd Grade —
Runnymede P. Farm—Bird No. 8: Score 1st Grade 265; 2nd Grade 3.
Under regulation total weight of 1st Grade eggs showed:—Bird No. 57 = 609 ozs.; Bird No. 8 = 576 ozs.

† R. Harrison—Bird No. 109: Score 1st Grade 206; 2nd Grade 2.
R. Harrison—Bird No. 112: Score 1st Grade 206; 2nd Grade 2.
R. Harrison—Bird No. 114: Score 1st Grade 206; 2nd Grade 1.
Under Regulation 21 total weight of 1st Grade eggs showed:—Bird No. 109 = 456 ozs.; Bird No. 112 = 455 ozs.; Bird No. 114 = 487 ozs.

DETAILED RESULTS—*continued.*

SECTION "B" (HEAVY BREEDS)—TEAMS OF SIX BIRDS.

Name of Competitor and Birds Nos.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	Totals. 1st.	Totals. 2nd.
G. Davey & Sons— 1—6	249	12	200	....	165	11	139	6	224	42	204	5	1181	76
Runnymede P.F.— 7—12	189	2	265	3	241	2	214	3	243	6	154	55	1306	71
A. Hampton (No. 1)— 13—18	141	1	182	56	73	12	166	31	154	....	206	4	922	104
A. Hampton— 19—24	199	21	253	1	231	2	201	26	152	63	239	7	1275	120
Hilltop P.F.— 25—30	172	43	95	32	175	3	203	11	132	28	93	5	870	122
E. E. Price— 31—36	219	5	194	20	203	....	178	43	127	105	107	1	1028	174
Thorne P.F.— 37—42	211	....	217	1	168	....	262	....	203	4	192	40	1253	45
G. W. Barker— 43—48	116	45	171	55	221	12	202	3	218	2	192	28	1120	145
Mrs. M. H. Dadley— 49—54	238	1	125	....	223	5	49	220	203	79	189	....	1027	305
M. H. Dadley— 55—60	244	1	231	2	265	....	254	2	250	6	244	43	1488	54
Robinson Bros.— 61—66	86	....	166	2	180	....	93	....	227	....	230	5	982	7
R. Harrison— 67—72	257	11	192	4	192	53	226	....	261	19	211	....	1339	87
A. S. Webb— 73—78	170	25	207	1	169	4	169	4	117	12	140	1	972	47
M. Wall— 79—84	205	24	220	16	176	32	245	1	162	4	247	2	1255	79
Wyndella P.F.— 145—150	176	2	176	10	264	....	134	....	221	....	179	1	1150	13
Cranleigh P.F.— 151—156	211	12	171	....	215	12	231	....	178	20	16	....	1022	44
F. Landquist & Son— 157—162	74	47	145	27	133	26	25	158	169	17	105	61	651	336
W. & E. Kerr— 163—168	218	13	197	....	171	1	260	1	267	1	206	....	1319	16

SECTION "C" (MEDIUM HEAVY BREEDS)—TEAMS OF SIX BIRDS.

Name of Competitor and Birds Nos.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	Totals 1st.	Totals 2nd.
F. B. Vickers— 85—90	21	....	186	45	104	118	188	29	164	73	199	18	862	283
F. Landquist & Son— 91—96	25	139	185	15	110	72	120	8	137	1	146	5	723	240
Hilltop P.F.— 97—102	155	53	74	70	77	62	135	21	105	62	109	8	655	276
Cranleigh P.F.— 103—108	54	64	211	31	198	....	146	4	190	2	171	53	972	154
R. Harrison— 109—114	206	2	183	....	198	10	206	2	173	....	206	1	1172	15
Runnymede P.F.— 115—120	173	1	51	19	90	1	174	....	156	3	133	30	777	54

Mortality.

The following is a comparison of the deaths for 1936-37 and 1937-38:—

	1936/37. Deaths.	1936/37. %	1937/38. Deaths.	1937/38. %
White Leghorns	6	6	7	7.3
Australorps	6	5.36	8	7.1
Rhode Island Reds	2	5.7	3	8

Note.—Two egg-eaters in 1937/38 were condemned and replaced.

Averages.

MONTHLY AVERAGES.

Month.	Breed.	Total No. of 1st Grade Eggs Laid.	Average.	Total No. of 2nd Grade Eggs Laid.	Average.	Total Average for all Grades.
April	W.L.	1016	10·58	255	2·65	13·23
	Aus.	1586	14·68	106	·98	15·66
	R.I.R.	420	11·6	31	·86	12·46
May	W.L.	1167	12·15	68	·70	12·85
	Aus.	1908	17·66	30	·27	17·93
	R.I.R.	554	15·38	9	·25	15·63
June	W.L.	983	10·23	175	1·82	12·05
	Aus.	1663	15·39	188	1·74	17·13
	R.I.R.	499	13·86	115	3·19	17·05
July	W.L.	1323	13·78	137	1·42	15·20
	Aus.	2039	18·87	116	1·07	19·94
	R.I.R.	458	12·72	65	1·80	14·52
August	W.L.	1824	19·0	145	1·51	20·51
	Aus.	2267	20·99	131	1·21	22·20
	R.I.R.	648	18·0	72	2·0	20·0
September	W.L.	1975	20·57	149	1·55	22·12
	Aus.	2314	21·62	162	1·51	23·13
	R.I.R.	601	16·69	114	3·16	19·85
October	W.L.	1987	20·69	280	2·90	23·59
	Aus.	2074	19·56	203	1·91	21·47
	R.I.R.	566	15·72	118	3·26	18·98
November	W.L.	1715	18·05	382	4·02	22·07
	Aus.	1889	17·99	243	2·31	20·30
	R.I.R.	437	12·48	148	4·22	16·70
December	W.L.	1442	15·50	469	5·04	20·54
	Aus.	1682	16·17	223	2·14	18·31
	R.I.R.	370	10·57	124	3·54	14·11
January	W.L.	1188	12·91	510	5·54	18·45
	Aus.	1422	13·80	246	2·38	16·18
	R.I.R.	307	9·02	120	3·52	12·54
February	W.L.	922	10·02	394	4·28	14·30
	Aus.	1316	12·90	197	1·93	14·83
	R.I.R.	301	8·85	106	3·11	11·96

YEARLY AVERAGES.

	1st Grade.	2nd Grade.	Average All Grades.
White Leghorns	163.68	31.13	194.81
Australorps	189.97	17.38	207.35
Rhode Island Reds	145.53	28.82	174.35

WINTER TEST RESULTS.

April 1st–July 31st (122 days).

Winners.	No. of Eggs.	Average 1st Grade Eggs.
Light Breed—H. P. Chalmer—White Leghorns	415	69.1
Heavy Breed—Mr. M. H. Dadley—Australorps	535	89.1
Medium-Heavy—R. Harrison—Rhode Island Reds ..	485	80.8

LAYING AVERAGES FOR WINTER TEST.

April 1st–July 31st (122 days).

	1st Grade.	2nd Grade.	Average All Grades.
Light Breeds—Leghorns	46.76	6.61	53.37
Heavy Breeds—Australorps ..	66.53	4.07	70.7
Medium-Heavy—Rhode Island Reds	53.63	6.11	59.74

DISCUSSION.

The results for 1937-38 are in every class higher than for the previous trials. It will be noticed also that the numbers laid by the first ten leading teams in each of the light and heavy breed sections are far ahead of the numbers laid in the preceding trial.

	1936/37.		1937/8.	
	1st	2nd	1st	2nd
10 pens White Leghorns ..	960.8	21.7	1,074.6	8.06
10 pens Australorps	1,128.6	12.11	1,268.6	7.06
*5 pens Rhode Island Reds ..	798.2	220.	901.2	149.1

*Rhode Island Reds entered for 1936/37 consisted of five pens of six birds, while in 1937/38 six pens were entered.

The above figures are remarkable. The improvements in one year give hope for a continued advance in the breeding for the large egg.

Section "A" (White Leghorns) improved by 114 first-grade eggs per pen of six birds. The second-grade eggs, although not counted but recorded, show that the White Leghorns have improved also in egg size.

Section "B."—The most prominent advance has been that of the Australorps, which have improved their pen average by 140 first-grade eggs. Here again the second-grade eggs have decreased.

Section "C."—The Rhode Island Reds have also shown improvement on the 1936-37 figures. Not only has the number of first-grade increased by 103 eggs, but the number of second-grade has decreased by 71 eggs per pen. There is room for a marked improvement in this breed. The number of eggs under 2 ozs. in weight is too high. It is hoped that an improvement will take place during the term of the current trial.

The following birds which laid 200 or more first-grade eggs during the 48 weeks were awarded a sealed copper ring:—

COPPER-BANDED BIRDS.

Copper Band No.	Trial No.	Breed.	Owner.	Number 1st Grade Eggs.
50	1	Australorp	G. Davey & Sons ..	249
51	2	Australorp	G. Davey & Sons ..	200
52	5	Australorp	G. Davey & Sons ..	224
53	6	Australorp	G. Davey & Sons ..	204

Copper-banded Birds—*continued.*

Copper Band No.	Trial No.	Breed.	Owner.	Number 1st Grade Eggs.
54	8	Australorp	E. O. Harrison ..	265
55	9	Australorp	E. O. Harrison ..	241
56	10	Australorp	E. O. Harrison ..	214
57	11	Australorp	E. O. Harrison ..	243
58	18	Australorp	A. Hampton	206
59	20	Australorp	A. Hampton	253
60	21	Australorp	A. Hampton	231
61	22	Australorp	A. Hampton	201
62	24	Australorp	A. Hampton	239
63	28	Australorp	A. W. Gregson ..	203
64	31	Australorp	E. E. Price	219
65	33	Australorp	E. E. Price	203
66	37	Australorp	H. Seal	211
67	38	Australorp	H. Seal	217
68	40	Australorp	H. Seal	262
69	41	Australorp	H. Seal	203
70	45	Australorp	G. W. Barker ..	221
71	46	Australorp	G. W. Barker ..	202
72	47	Australorp	G. W. Barker ..	218
73	49	Australorp	Mrs. M. H. Dadley ..	238
74	51	Australorp	Mrs. M. H. Dadley ..	223
75	53	Australorp	Mrs. M. H. Dadley ..	203
76	55	Australorp	M. H. Dadley ..	244
77	56	Australorp	M. H. Dadley ..	231
78	57	Australorp	M. H. Dadley ..	265
79	58	Australorp	M. H. Dadley ..	254
80	59	Australorp	M. H. Dadley ..	250
81	60	Australorp	M. H. Dadley ..	244
82	65	Australorp	Robinson Bros. ..	227
83	66	Australorp	Robinson Bros. ..	230
84	67	Australorp	R. Harrison	257
85	70	Australorp	R. Harrison	226
86	71	Australorp	R. Harrison	261
87	72	Australorp	R. Harrison	211
88	74	Australorp	A. S. Webb	207
89	79	Australorp	M. Wall	205
90	80	Australorp	M. Wall	220
91	82	Australorp	M. Wall	245
92	84	Australorp	M. Wall	247
93	147	Australorp	D. F. Robinson ..	264
94	149	Australorp	D. F. Robinson ..	221
95	151	Australorp	S. Dolman	211
96	153	Australorp	S. Dolman	215
97	154	Australorp	S. Dolman	231
98	163	Australorp	W. & E. Kerr ..	218
99	166	Australorp	W. & E. Kerr ..	260
100	167	Australorp	W. & E. Kerr ..	267
101	168	Australorp	W. & E. Kerr ..	206
102	104	Rhode Island Red	S. Dolman	211
103	109	Rhode Island Red	R. Harrison	206
104	112	Rhode Island Red	R. Harrison	206
21	2	White Leghorn	H. P. Chalmer ..	224
22	4	White Leghorn	H. P. Chalmer ..	243
23	6	White Leghorn	H. P. Chalmer ..	208
24	8	White Leghorn	E. E. Price	200
25	9	White Leghorn	E. E. Price	221
26	11	White Leghorn	E. E. Price	222
27	12	White Leghorn	E. E. Price	236

Copper-banded Birds—*continued.*

Copper Band No.	Trial No.	Breed.	Owner.	Number 1st Grade Eggs.
28	16	White Leghorn	H. Seal	201
29	19	White Leghorn	F. B. Vickers ..	213
30	21	White Leghorn	F. B. Vickers ..	216
31	26	White Leghorn	Mrs. M. H. Dadley ..	220
32	29	White Leghorn	Mrs. M. H. Dadley ..	234
33	36	White Leghorn	M. H. Dadley ..	228
34	38	White Leghorn	R. Harrison	230
35	40	White Leghorn	R. Harrison	204
36	44	White Leghorn	J. Duncan	216
37	64	White Leghorn	Mrs. R. Lowe ..	207
38	73	White Leghorn	W. R. Webb	229
39	78	White Leghorn	W. R. Webb	240
105	114	Rhode Island Red	R. Harrison	206

In 1936-37 69 birds qualified, while in 1937-38 75 birds gained the distinction. The percentage of copper rings gained in 1936-37 was 27.5 while in 1937-38 the percentage rose to 30 per cent., an increase of 2½ per cent.

The champion team was a pen of Australs entered by Mr. M. H. Dadley, of Coogee, via Fremantle. The total of 1,488 first-grade eggs was 195 higher than the leading team of 1936-37. It will be noticed that every bird in the team qualified for a sealed copper ring.

Mr. E. E. Price, of Hilton Park, via Fremantle, won in the White Leghorns section. His team laid 1,257 first-grade eggs, this being 38 in advance of last year's winners.

In Rhode Island Reds, Mr. R. Harrison, of Inaloo, Scarborough, won with a team laying 1,172 first-grade eggs. This was 40 eggs better than the year 1936-37.

Feeding.

In addition to the trial birds being tested at the College, the Poultry Branch of the College were testing breeders for their own use and therefore the feed used at the trials must be considered as having been fed to 271 birds in 1936-37 and 248 birds in 1937-38.

Feed Consumed.	1936/37.	1937/38.
Wheat	190½ bushels.	165½ bushels.
Pollard	186 „	191 „
Wheat Meal	6,798 lbs.	6,469 lbs.
Meat Meal	1,700 lbs.	1,962 lbs.
Bran	207 bushels.	178 bushels.
Bonemeal	747 lbs.	990 lbs.
Salt	84 lbs.	84 lbs.
	= 5.14 ozs. per fowl per day.	= 5.13 ozs. per fowl per day.

It is noticed—

(1) That the wheat feeding is less in 1937-38 than in 1936-37; and

(2) that the meatmeal consumption is higher in the 1937-38 trial; and

(3) that the bonemeal is higher in the 1937-38 trial.

The method of feeding has a marked impression on the respective consumption of the different foods. In the morning a wet mash is fed to all birds, irrespective of the breed, and a dry-mash hopper is open at all times in order to allow

the birds to have choice of extra food if required. The dry mash is mixed differently for each respective breed and it is here that the consumption has been found to be higher in 1937-38 than in 1936-37. This accounts for the smaller amount of wheat consumed in the latter year. The extra meatmeal consumed in 1937-38 has been due to the high fat content in some of the meal used. The fat content at times has been as high as 18 per cent. and this necessitated a higher percentage of meatmeal in the rations in order to obtain the correct balance.

The method of determining the meatmeal requirements in the ration has been to follow the colour of the droppings under the perches, together with the continual handling for condition.

The cost of feeding for the 48 weeks in 1937-38 was £127 1s. 5d., or equal to 10s. 3d. per bird, while the average return for eggs was 19s. 5¼d. The average profit therefore is 9s. 2¼d. per bird.

Note: Feeding costs are based on the retail prices of all goods as charged by metropolitan produce merchants whilst the returns for eggs are those received in open sales less 5 per cent. selling commission and a deduction of an account sales fee of 6d. per sales day (a sum equal to £2 12s. per annum).

AGRICULTURAL PROBLEMS.

Agriculturists, pastoralists and primary producers generally, who may be having difficulties of any kind in connection with their production activities, are invited to communicate with the Agricultural Adviser of their district of the Department of Agriculture, when information and advice will be supplied free of charge.

Where identification of plant or stock diseases or insect pests is required, full details of symptoms should be forwarded and also samples of the diseased plant, animal tissue or insect where practicable. Plant tissue intended for examination by the Plant Pathologist should be wrapped in paper and not forwarded in airtight containers, and plant specimens for the Botanist should be pressed between newspaper and dried before despatch. With regard to animal tissue for microscopic examination, this should be forwarded in a solution of 10 per cent. formalin, or if of considerable bulk in a sealed kerosene tin containing a few ounces of formalin as a preservative. Living insects should be sent in suitable containers and dead specimens in methylated spirits.

The addresses and names of Advisers are as follows:—

Albany	H. R. Powell
Bridgetown	A. Flintoff.
Bunbury	M. Cullity.
Geraldton	N. Davenport (Government Buildings).
Gosnells	R. C. Owen.
Harvey	R. L. Cailes (Fruit); A. M. Tindale (Dairying).
Katanning	A. S. Wild.
Kalamunda-Roleystone	W. H. Read, c/o. Department of Agriculture, Perth.
Kununoppin	W. M. Nunn.
Metropolitan, Gingin, Chittering ...	S. E. Bennett, c/o. Department of Agriculture, Perth.
Mundaring	V. Cahill.
Narrogin	A. T. Gulvin.
Vasse	J. M. Nelson.

HYDROPONICS.

The Growth of Crops in Water Without the Use of Soil.

L. J. H. TEAKLE.

Of recent years, particularly in the American press, there has been a considerable amount of attention given to the question of the commercial growing of crops in waters containing the ingredients necessary for plant growth. No soil whatever is used and immense crops have been reported.

As attractive references to this work have been made in publications available to Western Australian farmers (see a recent book by Bertrand Russell; "The West Australian Wheatgrower," of May 5th. 1938) and in view of certain inquiries from interested sources it is deemed appropriate that a statement be made on the subject.

The following information is derived from authoritative statements from the University of California Agricultural Experiment Station* and from other available reports.†

For three-quarters of a century scientists have been using water cultures as a means of ascertaining the requirements of plants. One of the foremost of the present-day investigators is Dr. W. F. Gericke, of the University of California, who has gone beyond the field of research and has proposed the method as a commercial means for crop production.

To Dr. Gericke is due the credit for the commencement of studies on a commercial scale and he and his collaborators have obtained sufficient data to show—

1. That hydroponics can succeed as a method of crop production.
2. The crop yield can be very high in terms of plant food used and area of ground required.
3. Special equipment and skilled attention is required for satisfactory results.
4. The skill of the gardener or farmer is just as necessary in the growth of crops in water culture as in soils and, in addition, a knowledge of the special technique peculiar to hydroponics is required.

A statement from the University of California discounts the importance of the reports of exceptionally high yields from water cultures and indicates that the yields from a fertile soil properly managed under glass-house conditions will be approximately the same as those from water cultures under the same conditions.

It is considered that "the method has certain possibilities in the growing of special high-priced crops, particularly out of season in glass-houses, in localities where good soil is not available, and where it is found too expensive to maintain

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* "Statement concerning water culture method of crop production," September, 1937.

D. R. Hoagland and D. I. Arnon—"Growing plants without soil by the water-culture method," February, 1938. (Extracts from this paper have been freely used in the preparation of this note.)

† W. F. Gericke—"Hydroponics—crop production in liquid culture media," *Science* 85 : 177-178, 1937.

"Crops in Water," *Californian Monthly*, February, 1938, p. 11.

G. O. Brehm—"What about Hydroponics?" *California Monthly*, February, 1938, p. 12.

highly favourable soil conditions. Soil beds in glass-houses often become infected with disease-producing organisms, or toxic substances may accumulate. Installation of adequate equipment for sterilising soils and operation of the equipment may involve considerable expense." The use of water culture, expertly supervised, may enable the grower more readily to control the conditions for plant growth, to eliminate certain diseases and to economise, perhaps, on fertiliser ingredients.

The term "hydroponics" for the new art in agriculture was suggested by Professor W. A. Setchell, of the University of California, and is a variation of the Greek word "geoponics" meaning agriculture. As "hydro" means water the new term merely means water culture but implies the use of water culture for the growth of crops on a commercial scale.

As with plants grown in soil, those grown in water culture will require similar external conditions. It will be just as essential to have adequate light, heat, air, carbon dioxide and water under one condition as under the other. The talk of growing crop plants in water culture in dim basements and otherwise unsuitable places is absolute nonsense. In fact, Mr. George O. Brehm of Seattle, Washington, found that tomatoes could be grown successfully with hydroponics in the summer months but during the winter period in which the hours of daylight would range from 8½ to 9½ hours, tomatoes failed to grow normally and to set fruit.

Claims have been made that the plants produced by hydroponics are more valuable nutritionally than those from soils. It is well known that the nutritional value of plants is determined in part by the quality of the soil and by the fertiliser used but there is no evidence that water culture is superior to soils. In fact, it is known that the composition of the plant varies with the composition of the water culture as well as with the soil, and the nature and management of the water culture will be as important in the food quality of the produce as with soils.

GROWING OF PLANTS IN WATER CULTURES.

"The usual equipment for the commercial water-culture method consists essentially of long, narrow, and shallow tanks, which may be constructed of wood, cement, black iron coated with asphalt paint, or other sufficiently cheap materials which do not give off toxic substances. These tanks contain the nutrient solution in which roots of the plant are immersed. Wire screens are placed over the tops of the tanks, or inside, above the solution. The screens support a layer of bedding of varying thickness (often 3 or 4 inches), according to the kind of plant grown. The bed may be prepared from a number of inexpensive materials—for example, pine shavings, pine excelsior,* rice hulls. Some materials, such as redwood shavings or sawdust, may be toxic. Seeds are planted in the moist beds, or young plants from flats set in them with their roots in the nutrient solution. It is to be noted that roots may develop not only in the solutions in the tanks, but also in the beds. The shallowness of the tanks and the porous nature of the beds facilitates aeration of the root system—an essential factor—although it has not been demonstrated that such aeration unsupplemented by an additional oxygen supply would be optimal for all kinds of plants."

As far as possible the ordinary fertiliser salts may be used for the preparation of the solutions. Care should be taken to be sure that these salts contain no injurious substances (for example, fluorine is commonly found in phosphatic fertilisers) which, while harmless in the soil, may be toxic in a water culture.

The temperature of the solution should not be allowed to vary greatly and it seems likely that approximately 70 deg. F. will be satisfactory for many plants.

* Fine wood wool.

Artificial heating is resorted to in some of the Californian installations to maintain the appropriate solution temperature and it seems likely that some cooling arrangements may be necessary during summer heat waves.

THE NUTRIENT SOLUTION.

The water solutions for the growing of the plants are made from salts dissolved in almost any water which is fit for drinking purposes. Water which is even slightly brackish or saline must be avoided.

The following salts are then dissolved in the water preferably in the order mentioned:—

Salt.	Amount per 25 gallons of water.	
	Ounces.	Tablespoons.
mono ammonium phosphate	½	1 heaping.
potassium nitrate	3	6 level (powdered salt).
calcium nitrate	3	7 level.
Epsom salts (magnesium sulphate)	1¾	5 level.

An alternative solution may be prepared as follows:—

Salt.	Amount per 25 gallons of water.	
	Ounces.	Tablespoons.
potassium phosphate (monobasic)	½	1 level.
potassium nitrate	2½	5 level (powdered salt).
calcium nitrate	3½	8 level.
Epsom salts (magnesium sulphate)	1¾	5 level.

To these solutions certain "minor" elements must be added in small amounts.

1. *Iron Solution.*

"Dissolve a level teaspoon of iron tartrate (iron citrate or iron sulphate can be substituted, but the tartrate or citrate are often more effective than the sulphate) in a quart of water. Add half a cupful of this solution to 25 gallons of nutrient solution each time iron is needed (once weekly, or more frequently if the plants are pale)."

2. *Boron Solution.*

"Dissolve a level teaspoon of powdered boric acid in a gallon of water. Use a pint and a half of this solution for each 25 gallons of nutrient solution."

3. *Manganese Solution.*

"Dissolve a teaspoon of crystalline, chemically pure manganese chloride ($MnCl_2 . 4 H_2O$) in a gallon of water. Manganese sulphate can also be used. Dilute one part of this solution with 2 parts of water, by volume. Use a pint of the *diluted* solution for each 25 gallons of water."

4. *Zinc Solution.*

"Dissolve a level teaspoon of crystalline, chemically pure zinc sulphate ($ZnSO_4 . 7H_2O$) in a gallon of water. Use 4 teaspoons of this solution for each 25 gallons of nutrient solution."

5. *Copper Solution.*

"Dissolve a teaspoon of chemically pure copper sulphate ($CuSO_4 . 5H_2O$) in a gallon of water. Dilute one part of this solution with 4 parts of water; use one *teaspoon* of the *diluted* solution for each 25 gallons of nutrient solution."

Furthermore, the growth of the plant causes the solution to become alkaline and it must be adjusted to the more favourable slightly acid condition (pH6).

This is done by means of 3 per cent. sulphuric acid as follows:—

Take exactly one quart of the solution in a white porcelain dipper and add sufficient brom thymol blue indicator* to give a visible colour. A yellow colour indicates slight acidity when no adjustment is necessary. Green is indicative of a neutral reaction and blue an alkaline reaction. If the indicator gives a green or blue colour add the 3 per cent. sulphuric acid from a burette to the quart of solution until it *just* turns yellow. Carefully note the amount taken by reading the burette and then add just one hundred times as much of the acid to the 25 gallons of solution to effect the same adjustment. If the volume is not 25 gallons a proportionate amount should be used.

This test with the indicator should be made every day or so during the growth of the plants and adjustment made with the acid when necessary.

TANKS AND OTHER CONTAINERS FOR NUTRIENT SOLUTIONS.

"Various kinds of tanks and containers have been utilised for growing plants in water culture. Tanks of black iron, well painted with asphalt paint (most ordinary paints cannot be used, because of toxic substances), have proved satisfactory for experimental work. Galvanised iron may give trouble, even when coated with asphalt paint, if the paint scales off.

"Concrete tanks have been tried, but they may require thorough leaching before use. Painting the inside of the tank with asphalt paint is advisable. Wooden tanks will serve the purpose, if made watertight.

"The dimensions of tanks must be selected in accordance with the objective. One kind of tank, of large size, adapted to many purposes, has dimensions of 10 feet in length, 2½ feet in width, and 8 inches in depth. A smaller tank, 30 inches long, 12 inches wide, and 8 inches deep, is convenient for use in many experiments. In general, shallow tanks will be found suitable. The length and width may be determined by consideration of convenience.

"A heavy chicken-wire netting (1-inch mesh), coated with asphalt paint, is fastened to a frame and placed directly over the tank to provide support for the porous bed. In constructing a frame, it is desirable to leave several narrow sections not covered with wire netting, but with wooden covers which can be conveniently removed for inspection of roots, or for adding water or chemicals. The wire netting should be stretched immediately above the surface of the solution, when the tank is full. Cross supports may be placed under the netting to prevent it from sagging.

"A carpenter or mechanic can design and build suitable tanks and frames, which may take many forms, and further detailed description is unnecessary for the purpose of this circular."

* Obtained from the wholesale drug stores in Perth.

NATURE OF BED.*

"The wire screen is covered by a layer of porous bedding material several inches thick—thicker when tubers or fleshy roots develop in the bed. Various cheap bedding materials have been suggested: pine excelsior (fine wood wool), peat moss, pine shavings or sawdust, rice hulls, etc. Some materials are toxic to plants. Redwood should usually be avoided. One type of bed which has produced no toxic effects in experiments carried on in Berkeley, with tomatoes, consists of a layer of pine excelsior, 2 or 3 inches thick, with a superimposed layer of rice hulls about 1 or 2 inches thick. For plants producing tubers or fleshy roots, some finer material may need to be mixed with the excelsior. This is also essential when small seeds are planted in the bed, to prevent the seeds from falling into the solution and to effect good contact of moist material with the seed. In all cases, the bed must be porous and not exclude free access of air.

"If seeds are planted in the bed, it must, of course, be moistened at the start and maintained moist until roots grow into the solution below. The bed should also be maintained in a moist state, by occasional sprinkling, for the development of tubers, bulbs, fleshy roots, etc. *Great care should be observed to prevent water-logging of the bed, which leads to exclusion of air and to undesirable bacterial decompositions.*"

PLANTING PROCEDURES.

"Seeds may be planted in the moist bed, but often it is better to set out young plants chosen for their vigour, which have been grown from seeds in flats of good loam. In transplanting from a flat of soil, the soil is thoroughly soaked with water so that the plants can be removed with the least possible injury to the roots. The roots are then rinsed free of soil with a light stream of water and immediately set out in the beds, with the roots immersed in the solution. If young plants are set out, the roots are placed in the solution, and at the same time the layer of excelsior is built up over the screen. Then the layer of rice hulls is placed on top of the excelsior. If seeds are to be planted in the bed, the whole bed must be installed and moistened before the seed is planted."

SPACING OF PLANTS.

"In the experiment with tomato, plants were set close together, in some instances 20 plants to 25 square feet of solution surface. No general advice can be offered as to the best spacing. This depends on the kind of plant and on light conditions. Individual experience must guide the grower."

ADDITION OF WATER TO TANKS.

"In starting the culture, the tank is filled with solution almost to the level of the lower part of the bed. As the plants grow, water will be absorbed by plants or evaporated from the surface of the solution, and the level of the solution in the tank will fall. The recommendation has generally been made that after the root system is well developed, the level of the solution should remain from one to several inches below the lower part of the bed, to facilitate aeration. However, since the solution level should not be permitted to fall very far, regular additions of water are required."

* The general arrangement of this type of bed was first described by W. F. Gericke and J. R. Tavernetti. *Agricultural Engineering*, 17 : 141-43, 1936.

CHANGES OF NUTRIENT SOLUTION.

"As the plants begin to grow, nutrient salts will be absorbed and the acidity of the solution will change. More salts and acid may be added, but to know how much, chemical tests on the solution are required. When these cannot be made, an arbitrary procedure may be adopted of draining out the old solution every week or two, immediately refilling the tank with water, and adding salts and acid, as at the beginning of the culture. The number of changes of solution required will depend on size of plants, how fast they are growing, and on volume of solution. Distribute the salts and acid to different parts of the tank. In order to effect proper mixing, it may be well to fill the tank at first only partly full (but keep most of the roots immersed) and then after adding the salts and acid, to complete the filling to the proper level with a rapid stream of water."

Another method of maintaining the supply of fertilising ingredients is to make up a strong solution of the substances listed above and to add a little of this each week or as the plants show signs of under-nutrition. If the quantities listed above are dissolved in one gallon instead of 25 it will form a strong stock solution. A cupful of this solution mixed with the culture solution every week when the plants are growing vigorously or whenever the plants show signs of losing their natural green colour should suffice.

CROWN PACK FOR APPLES AND PEARS.

Report made by Mr. A. FLINTOFF, Horticultural Instructor, upon his return from Tasmania.

In reporting on my visit to Tasmania in connection with the "Crown" method of packing apples and pears, I have to state that I spent a fortnight in that State during which time I was accorded the best of treatment from Mr. P. H. Thomas and his officers. No effort was spared in order to show me most that would be of interest regarding the special mission that was the purpose of my visit.

The South, Central and Northern centres were visited and many fruit packing establishments gave us the opportunity of examining the various methods of putting up apples and pears for export. I was also given bench room in order to put into practice the principles of "Crown" packing which had already been explained at Hobart Headquarters.

I may state that Mr. M. Large is the packing instructor in the south and Mr. K. Pearce in the north. I found both these officers very desirous of making my stay pleasant as well as instructive.

In regard to the boxes used for apple and pear packing, I note that various types are in commission—all hard woods (native) which are light coloured and, if well cut are quite presentable: a box which the Tasmanians term a "Shandy" case, ends and sides hard woods, tops and bottoms imported pine; and a wholly softwood case (imported pine). Of the three types, the all softwood case is most favoured by keen growers and also by Government officials, these cases being clean, well cut and attractive.

The "Shandy" case, because of being a little cheaper, is favoured in some quarters and, if well cut and clean the difference in colour between tops and bottoms, and the body of the case is not very pronounced as the Tasmanian hard woods are light in colour.

The all hard wood is a shade cheaper again, but is not favoured to date by packers using the "Crown" pack, as the tops and bottoms are not sufficiently flexible and appear to put undue pressure on the fruit when the case is being nailed down.

At Hobart I inspected packed cases of all types and certainly the imported wood showed to advantage. Regardless hardwood tops and bottoms. I examined cases at Mr. Cotterell's sheds in Hobart. These are packed wood. I understand the tops are softwood and then "veneer" from the wood. There seems some practice in this method of obtaining thin boards from hard wood. The thin is weakened across the wood, but longitudinal grain appears unimpaired. This weakening of

Standard bushel case. Crown pack. Side view.

the fibre prevents any "curl" of the boards and, in actual practice, the boards under the nailing down press seem to hold over the fruit satisfactorily. In the event of Western Australia ultimately using the standard case, this method of cutting tops and bottoms from hard woods may be worth consideration. A saving of 25 per cent. in timber as against the sawn cut boards is claimed.

Tasmanian growers have practically discontinued the use of the Australian bushel case for export other than when sending to mainland States.

In reference to the "Crown" method of packing apples and pears, not all packers have made the change over from the usual high straight to the pack. Naturally, growers look upon the innovation as upsetting the established routine of the shed work.

Standard bushel case. Crown pack. Side view with side removed.

Mr. Thomas, however, is making every effort to bring about its universal adoption. To packers who understand the principles governing the packing of apples and pears, the change over represents no difficulty and a few days' practice with the different sizes in fruits will suffice to familiarise the packer with the whole operation.

Of course, there are certain sizes of fruit that require care in arrangement in order to bring the final layer to the correct height, but this refers to any fruit case in use. The packing of apples and pears in the Standard case is simple in comparison with the system used with the Australian Bushel, there being no diagonal packs. The box (Standard) being 10½ inches deep as against the Australian bushel depth of 14¼ inches also simplifies the operation. The "pack" used previously (and still used in many sheds) is what may be termed the high flat pack, the bulge being forced into the lid by the high fruit at each end of the case.

In the "Crown" pack, the principle lies in "building" the bulge into the *fruit* so that the lid, being flexible, "lays" over the fruit and with a well-packed case, no great pressure is needed when nailing down.

The actual packing of the fruit as advised and taught by Mr. Thomas is as follows:—

The first layer is packed as per chart leaving out the last "set" of fruit. The second layer is then proceeded with until the end of the first layer is reached. At this stage both hands are used to pull back the first or bottom layer. This action has the effect of partly "bunching" up the fruit midway in the case. The finishing fruits are then placed in the bottom layer and the pack proceeded with. In each layer, including the second, the fruit is placed in the "pockets" provided by the previous layer in the usual sequence, but as the fruit is placed in the pockets at the sides and ends of the case a firm downward pressure is exerted, the central fruits being simply laid on the "pad" formed by the paper. No appreciable extra time is absorbed in this firm pressure action. As each layer is added in the same way, the crown is being built so that, with the finishing layer, the "Crown" is such that the fruit appears to dome from sides and ends. The difference in fruit weight, high flat pack v. Crown, is not great, but the disposition of fruit in the "Crown" keeps the side and end fruit comparatively low.

In every instance the calyx of the fruit faces the end of case, *i.e.*, the commencing and finishing fruit of each layer is turned so that the calyx faces the wood, also the fruit is so placed as to show what is termed a four-side inspection. The first layer is wrapped in such a way as finally to go into the case with the finishing paper "tails" upwards. All fruits are placed then so that should the case be opened either top, bottom or sides, no paper tails are showing.

The finish of the "wrap" shows a half twist on the paper.

I have attempted to detail the operations as advocated by Government officials. Some deflections from this ideal are sure to be made and I certainly found this to be the case. When in the north of the State I spent several days with the Government Packing Instructor, Mr. K. Pearce, who followed two seasons in the States of America. Mr. Pearce does not follow in detail the ideal above mentioned. No doubt he finds that growers are a little antagonistic regarding the exactness of the above-mentioned operation.

I understand that the twist of the paper is not generally followed in America, and in fact, Mr. Pearce does not use it. Furthermore, the turning up of paper tails in the first layer is not generally practised. Nor is the temporary non-completion of the first layer considered of prime importance. In eliminating these "extra" movements it is claimed that time and annoyance are saved.

Standard bushel — Crown pack. End view.

The following method, as practised by many reputable growers, appeared to me commercially sound. The photographs enlarged were taken from results of this pack:—

First layer is *completed,* fruit placed with "pad" of paper *down.* Calyx of fruit facing case at each end.

Second and succeeding layers continued in the order as before explained, firm downward pressure on outer fruit, central fruit resting more or less lightly on paper "pads."

No half-twist when completing the wrap. Although the underhand wrap, as practised by Mr. Pearce, is very satisfactory, many packers rather "slum" the finish of this wrap, sacrificing neatness for a little extra speed. Paper tails must be turned in on sides of cases as sides are practically the only places opened for inspection, that is, with the "standard" case.

I consider that the "Crown" method of packing apples and pears is superior to the usual flat high packs used previously, the main reason being that the same weight of fruit (perhaps a little more) is more easily built into the case and presents a better proposition for lidding, as the fruit is lower at ends and sides, the general pack having more "spring." It is claimed that to get the previous high flat packs different sizes in fruits were used, that is smaller fruits at each end. This appears to have been the general practice.

With the "Crown" pack such is not entirely the case, at the same time a good packer will often place rather smaller fruit at the ends. This has been practised also with the Australian bushel case.

COMPARATIVE FRUIT WEIGHTS.

From time to time statements have been made regarding the difference in weights (Standard v. Australian bushel) of fruit in a packed case, some, to the effect that there is a difference of 4 to 5 lbs. in favour of the standard case. That is to say, taking medium sized 2½-inch apples at 4 to the pound, there would be at least 16 apples more in a standard. This may have been so some years ago when the Australian bushel case was undersized and weight parity round about 38 lbs. net for Jonathans.

Since returning to Bridgetown, I have gone into this matter in accordance with your instructions with both pears and apples. With Jonathans, our lightest export apple, 42 lbs. av. nett weight can be packed into a correctly sized case. With the "Standard" case the average nett weight is approximately 44 lbs.

Tasmanian chart gives this average for Jonathans. I was careful to use the same apples when testing these weights packing the same fruit from one type of case to the other.

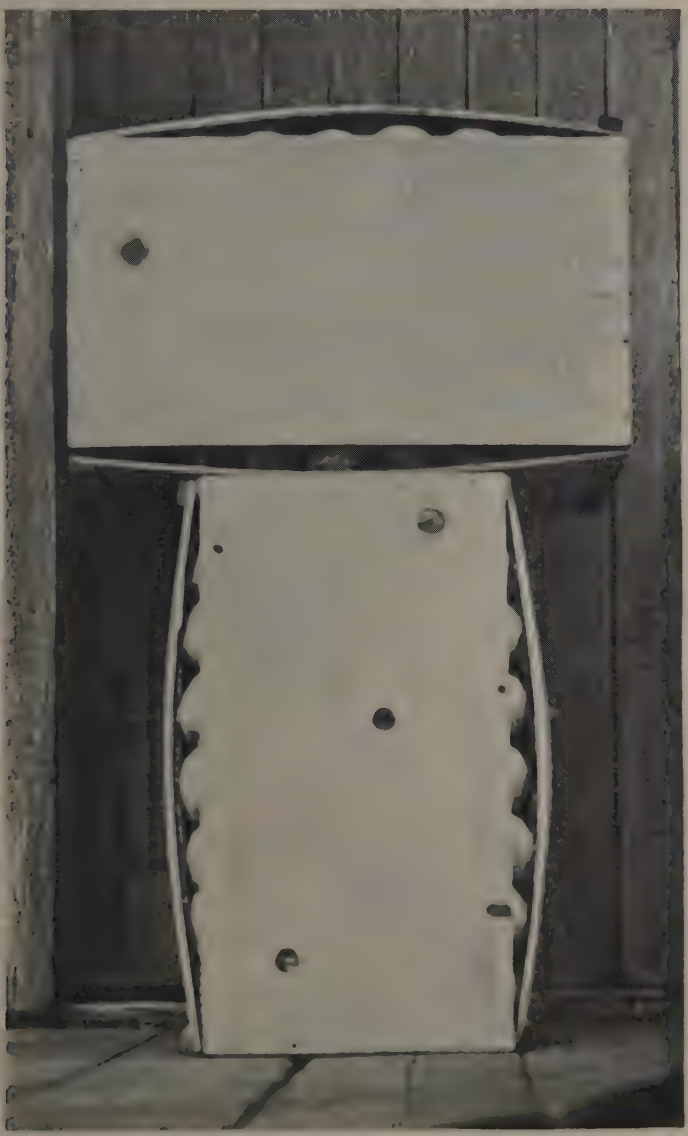
As a general rule the chart numbers vary to the extent of 5 to 8 apples. *i.e.*,

Australian	Bushel	175	count	is	"Standard"	180
"	"	144	"	"	"	150
"	"	193	"	"	"	198
"	"	132	"	"	"	138
"	"	120	"	"	"	125
"	"	108	"	"	"	113

It is obvious that round about 1½ lbs. to 2 lbs. more weight is in favour of the standard case.

There is a little difficulty in comparison of counts as Tasmanian fruit is largely packed to count. Thus a case packed to count and not to size may contain

say 50 per cent. of large 2½-inch and 50 per cent. small 2¾ with possibly no more than ⅛-inch variation in size of fruits within the case. Under the regulation branding to size would rule this pack out. Yet in certain packs, say our very large



Standard bushel case. Crown pack. Cases nailed down.

2¼ Granny Smith 140 apples 5 x 5 — 2 x 2 straight pack it is almost essential, if one would put the correct weight of fruit (44 lbs. nett) to use some apples just over the large 2½-inch.

I have to hand enlargements of photos of packed apples. The fact that the cases are lying quite flat rather accentuates the bulge and in that respect is slightly misleading as, even if the case was on the ordinary packing stand the side apples would show about ¾-inch lower. Otherwise, I consider the illustration will serve a purpose.

"CROWN" PACK IN AUSTRALIAN BUSHEL.

Having tested out the "Crown" method of packing our bushel case, I am convinced that a modification of the system can be used with advantage. Obviously the comparative narrowness of the dump does not lend itself to building up from the sides, but end to end the measurement is the same.

I have tried the system in several ways and am fairly confident that the end fruits can be kept down and so eliminate that objectionable feature of high end apples as seen so frequently in our general packs.

Regarding pear packs, I have tried out several sizes in Winter Nelis only and find it easy to get 45 lbs. nett in the standard pear case.

THE MOVEMENT OF SOLUBLE SALTS IN SOILS UNDER LIGHT RAINFALL CONDITIONS.

By L. J. H. TEAKLE and G. H. BURVILL.

It is universally recognised that soluble salts are liable to accumulate in soils where the rainfall is light, that is, where it is insufficient in amount to cause a movement of water *through* the soil into the drainage system. These conditions are generally indicated by the occurrence of a very slightly soluble salt, calcium carbonate, in the subsoil and, in the agricultural areas of Western Australia, occur where the annual rainfall averages less than about 15 inches. Associated with the calcium carbonate will be found certain soluble salts and, of these, in Western Australia sodium chloride is by far the most important. Sodium chloride constitutes from 10 or 20 per cent. of the total water soluble salts where the concentration is low, to about 80 per cent. where the concentration is high. Generally for soils in which the concentration of water soluble salts is above 0.50 per cent., the proportion of sodium chloride is of the order of magnitude of 60 to 70 per cent.; in fact, the proportion is similar to that in sea salts.

By way of definition it may be stated that *low* rainfall areas are those having a *low* average annual precipitation—say less than 15 inches in Western Australia. The *light* rainfall portion of the State receives less than 20 points of rain per wet day and stretches from the eastern wheat belt eastwards into South Australia.

A question of vital importance in some districts in Western Australia is the movement of water soluble salts in the soil following the clearing of the timber. The answer to this question is afforded by the results of five years' experience in the course of soil surveys in the wheat belt under rainfall conditions ranging from 11 to 16 inches per annum. As chlorides are the principal constituents of the water soluble salts fraction and as chloride moves somewhat more readily in the soil than other ions, a study of the movements of chlorides is taken as a basis for the conclusions arrived at. In most of the work, the chlorides were determined by Best's (1929) method while the conductimetric procedure described by Samuel and Teakle (1931) was used to give a measure of the total water soluble salts. A number of check samples were examined by the usual gravimetric procedure.

As any movement of water soluble salts will be conditioned largely by moisture movements some review of the current viewpoint concerning water movements in soils must be attempted.

Moisture Movement in Soils.

The phenomenon of capillarity, and the possibility of the movement upwards of moisture and, with it, other materials by capillarity, have long interested soil investigators. The action of the sun, in evaporating moisture at the surface, was presumed to supply the energy for drawing moisture from extraordinarily great depths by virtue of the phenomenon of capillarity. On theoretical grounds Mitscherlich (1901), in Germany, calculated that the maximum possible capillary rise in heavy clays and loams would be of the order of magnitude of two miles. Sir Daniel Hall (1912, p. 99) supported the idea but considered that movement may be expected from a depth of 200 feet. Cameron, in America, held similar views and also imagined the waters rising by capillarity to bring up important supplies of phosphate and potash. Keen (1919) estimated that in an "ideal" clay, capillarity would be effective over a theoretical maximum height of 150 feet. Similar considerations are the basis of an explanation of the formation of "laterite" offered by some geologists.

It is very fortunate that field and experimental evidence does not support these theories, as, otherwise, where leaching is not very effective and where long dry spells occur, the surface of the soil would be a "crust" of salts and quite unsuitable for the growth of the present types of plants. When columns of dry soil are stood in water, capillary rise occurs, but the rise is generally of the order of magnitude of two to three feet. The more powdery and silty soils are most active and may raise water to a height of four or five feet while the maximum capillary rise recorded seems to be for a finely ground rock flour, with particles of .005 mm to .016 mm diameter, for which Loughridge obtained a height of 122 inches in 18 months (see Hilgard, (1912, p. 203)).

Alway and McDole (1917) review the situation and find that in actual practice capillary action in soil is generally of small importance. Plant roots go for water and nutrients as these do not move towards the roots by capillarity to a sufficient degree to supply requirements. They cite Canadian experience which indicates little or no loss of water from the soil by evaporation at depth greater than one foot. Also, Rotmistrov made an exhaustive field study near Odessa* under conditions where the permanent water table was over 100 feet from the surface. It was observed that the subsoil was permanently moist below the zone of root action but no water percolating below a depth of 16 to 20 inches ever returned to the surface except via the roots. Below this depth, water not absorbed by the roots goes down, apparently in annual waves, at the rate of about 7 feet per annum at Odessa. Alway and McDole also cite the conclusion of Leather at Pusa, India, that the maximum distance from which water moved upwards was 7 feet.

Vaidhianathan and Luthra (1934) consider that the upward movement may be felt as deep as 22 feet in the Punjab Irrigation area.

This view is supported by further evidence from the 1936 annual report of the Punjab Irrigation Research Institute cited in Monthly Letter No. 69 of the Imperial Bureau of Soil Science. In the work of the Institute "it has been shown that soil deterioration due to salinity may take place when the water table reaches

*Odessa has an average annual rainfall of about 17 inches (425 mm.) based on 30 years' records 1866 to 1895. The precipitation is fairly evenly distributed by months as the monthly averages range from about 1 inch to 2 inches. The maximum monthly recordings are for June and July.

a depth of 18 feet from the surface, if the groundwater or soil profile contains sodium salts." These figures are in excess of those generally accepted by modern opinion and it is suggested that the climatic conditions of the Punjab are an important factor in the divergence.

A valuable contribution to the problem has been made by Wadsworth (1931) who shows that capillary movement upwards is active only at *field capacity*† or higher moisture figures. Other investigators have shown that movement from a moist soil—below field capacity in moisture content—to an air dried soil is practically non-existent beyond raising the dry material to the hygroscopic coefficient or the moisture content in equilibrium with a saturated atmosphere.

An interesting series of experiments by Shaw and Smith (1927) provide important data for sandy loam and loam soils in California. Columns of soil at field capacity were stood in water at depths ranging from 4 to 10 feet and a current of warm air gently blown across the surface of the soils. The loss of water from the reservoirs was measured and shows that loss is rapid where the water table is within 4 feet of the surface. A slow loss is obtained where the column of soil is 6 feet above the free water level and a significant loss was measured in the loam soil from a depth of 8 feet. Practically no loss was observed when the water table was at 10 feet.

In heavy clay soils Childs (1936 a and b) and Nicholson and Childs (1936) show that the laws of diffusion and not those of capillarity fit the experimental data for moisture movement.

Veihmeyer (1927) has shown that moisture movement in soils is very slow when the moisture content falls below the field capacity. At higher moisture contents the soil moisture in the subsoil below 16 to 20 inches will always move downwards, unless absorbed by plant roots, and will carry with it the water soluble salts. Thus the danger of a general rise of salt from the subsoil, except where a shallow water exists or where special soil conditions occur, is non-existent.

From all of this evidence it seems that the following practical conclusions regarding moisture movement in soils may be reached:—

(1) Capillary is not effective except over short distances in the soil mass and plant roots grow to the supplies rather than being fed by capillarity.

(2) Capillarity is active in soils only at moisture contents at or above field capacity.

(3) The extent of capillary movement of water upwards from a free water surface depends on the soil type and ranges from a few inches in sands to four or six feet in ordinary soils and five to 10 feet in certain silty soils and materials such as finely ground rock flour.

(4) Under field conditions where no water table exists, loss of water by surface evaporation will be generally confined to the surface 12 to 20 inches. It is considered that further loss will be due to the escape of water vapour from within the soil mass. Where an impervious subsoil causes the surface layers to become waterlogged or maintained at or above field capacity for any length of time, capillarity becomes a factor in the loss of water from greater depths by surface evaporation.

† Field capacity may be defined as the amount of water held in the soil under field conditions as soon after an irrigation or heavy rain as the excess moisture has been removed by drainage.

(5) Both capillarity and diffusion will be factors in moisture movement in soils over short distances.

(6) Under the influence of gravity the predominant tendency will be for movement of moisture to be downwards.

The data which are now to be presented on the movement of soluble salts in soils under light rainfall conditions may be conveniently grouped under three headings:—

A. Surface accumulations of soluble salts.

B. The effect of clearing the natural vegetation on the movement of soluble salts in the soil under an 11- to 16-inch rainfall.

C. The movement of salts in fallowed soils in tanks at the Merredin Research Station.

A.—SURFACE ACCUMULATIONS OF SOLUBLE SALTS IN SOILS.

Conditions under which surface accumulations of soluble salts are liable to occur in soils must be recognised for a proper appreciation of the incidence of soil salinity. Of course, where the rainfall is adequate, the general movement of salt is *downwards* into the drainage system. Thus Weller (1926) found that the amount of salt annually entering the Mundaring reservoir, near Perth, where the average rainfall is about 40 inches, approximates that deposited each year on the catchment by the rainfall. With lower, and more especially with light rainfall conditions, a much smaller proportion of the rainfall finds its way through the soil into the drainage system. If circumstances arise which allow its return to and evaporation from the surface of the soil, then surface accumulation of soluble salts occurs and may become an important agricultural problem.

Light rainfall areas will generally be most liable to salt problems. In the light rainfall areas of Western Australia surface accumulation of soluble salts is observed to occur under at least five conditions—

1. Where a high water table exists;
2. From evaporation of seepage water;
3. On the rims of crabholes; where the micro-relief and texture favour surface evaporation;
4. Where special soil characters lead to the establishment of capillary connection between a saline subsoil and the surface in the absence of a shallow water table;
5. Surface concentration on areas with saline subsoils but without unusual micro-relief or structure.

1. *The Danger of a High Water Table.*

The most serious surface accumulations of salts in soils in agricultural practice are most generally associated with irrigation projects in which excess of water is used without adequate provision for drainage, and the water table rises.

In the United States of America a million acres of valuable irrigation land has been virtually ruined by the surface accumulation of soluble salts resulting from the excessive application of irrigation water which led to a rise in the water table. At Billings, Montana, the water table, prior to the introduction of irrigation, ranged from 20 to 50 feet deep, but within 12 to 15 years from the commencement of watering had been raised from 3 to 10 feet of the surface. In many instances test wells showed water containing 0.3 to 0.5 per cent. water soluble salts at less than five feet from the surface and low-lying areas had become bogs and salt swamps. At Fresno, California, where the water table had originally stood at about 30 feet deep, excessive irrigation resulted in a fluctuating water

table standing at two to three feet below the surface during the summer months. Similar conditions have developed in Utah irrigation areas. Surface accumulation of water soluble salts has caused severe damage to crops in each of these instances.

Review of the situation in the United States of America generally shows that two factors are of paramount importance in the vertical distribution of salts in soils—

(a) the character of the soil;

(b) the depth of the water table.

Sandy soils, with low capillary powers, could be managed and maintained free of salt in the surface with a water table not less than three feet from the surface. A depth of four feet is recognised as more desirable. With other soil types greater depths are necessary, as serious surface accumulations are generally observed where the water table is as shallow as four or five feet in midsummer. Little trouble is ever experienced with the water table at 10 feet or lower.

Conclusive supporting evidence is available from many sources. Thorp (1936, p. 178), describing saline delta soils in China, finds that where the brackish subsoil water is deeper than five or six feet during the dry season, the upper soils contain little salt and good crops of wheat, barley, cotton, etc., may be grown. However, where the water table, either permanent or perched, is less than 4½ to 5 feet during the dry season, surface encrustation of salt occurs as a result of capillary movement.

In the Western Australian wheat belt, under a rainfall of 11 to 15 inches per annum, low-lying country carrying certain teatrees and characteristic eucalypts in the virgin state, and having the appearance of filled-in lake or river channels, have become affected with salt in the course of 10 to 20 years of development. This is associated with the rise of the salt water table due to seepage into these low-lying areas. (See Table 1.) Instances observed on farms at Moulyinning, Wagin, Carnamah and Broomehill may be mentioned to show that where the saline subsoil water has risen to less than 5 or 6 feet of the surface in such valleys and flats, surface accumulation of salt is very likely to occur.

The results of observations in the Lake Brown district in Western Australia are thought to lend general support to these conclusions as surface salt accumulations, in the form of bare patches, in relatively heavy textured soils are liable to occur where the salt water table is as deep as 10 to 11 feet below the surface.

It seems that the best that can be done under these circumstances is the fostering of pasture plants such as wimmera rye grass, barley grass, salt bushes, etc., which may take possession of portions of the areas. Certain cheap drainage works may be advisable in some cases but will generally be too expensive to undertake.

2. *Evaporation of Seepage Water.*

In Western Australia, a common cause of salt accumulation is seepage of water which results from the clearing of large tracts of country in the course of development. When the country was virgin the vegetation largely controlled the movement of soil moisture but when this was removed percolation increased, springs developed and creeks, previously dry for most of the season, became more or less permanent sources of water. This seepage and subsoil water varies from quite good domestic quality (about 50 to 100 grains of total water soluble salts per gallon) to brackish (say 700 grains per gallon) and highly saline (3,500 grains per gallon). (See Table 1.) With long continued periods of evaporation, even with good or brackish water sufficient quantities of salts are brought to the surface to produce saline soils. These saline patches occur on slopes and on the banks of creeks throughout the agricultural areas but, in most cases, do not extend to more

than a few acres on any one farm. In a recent investigation at Broomehill it was observed that these patches developed where the brackish seepage water or "stream" came within less than about four feet of the surface. They are very obvious and undesirable, nevertheless, and should be prevented as far as possible by proper control of seepage water. Establishment of water-absorbing pasture and forage plants, in some instances supplemented by drainage, should, in most cases, effect control.

TABLE 1.

Salt Content of Subsoil Water, Water of Springs, Salt Dams, Shallow Wells and Bores in the Agricultural Areas.*

Serial No.	District.	Depth. (feet).	Salt.	
			Per cent.	Grains per Gallon.
1	Moulyinning	5	3·22	2,250
2	do.	3	2·83	1,980
3	do.	2½	1·09	763
4	do.	soak	0·34	238
7	Boodarockin	14	5·01	3,510
8	Campion	11	5·27	3,690
13	Wyalkatchem	3	1·52	1,060
32	Hindmarsh	19 (bore)	2·66	1,860
33	do.	30 (bore)	0·78	546
53	do.	11 (bore)	0·12	84
54	do.	9 (bore)	0·52	364
79	Cleary	8 (soak)	1·12	784
80	do.	12	5·07	3,550
81	do.	11	4·72	3,300
83	do.	5 (in clay pan)	3·25	2,280
82	Beacon Rock	35 (bore)	3·19	2,230
12	Corrigin	3	2·15	1,500
89	Moora	Pool in creek (December)	1·00	700
90	do.	Same pool (February)	1·72	1,204
21	Wagin	Dam	1·67	1,170
22	do.	Dam	1·30	910
23	do.	Soak	0·113	79
24	do.	5	0·087	61
25	do.	Spring	1·55	1,080
27	do.	Well	1·14	798
28	do.	Spring (adjacent 27)	1·12	784
29	do.	20 (well)	2·42	1,690
30	do.	3½	3·47	2,430
52	Katanning	Dam	1·92	1,340
9	Salmon Gums	6	5·92	4,140
10	Grass Patch	12	3·85	2,700
11	Kumarl	20 (well)	0·425	298
84	Bridgetown	Soak in creek	0·25	175
86	do.	10 (well)	0·47	330

* Salt expressed as NaCl calculated from total chloride.

NOTE.—Sea water contains 3·13 per cent. salt as NaCl calculated from total chloride.

3. *Evaporation from the Rims of Crabholes.*

In the drier parts of the wheat belt are areas of heavy soils which show an uneven surface, with many depressions known as crabholes or gilgais. These crabholes vary from 10 to 30 feet across, and from 2 to 6 feet deep, and in the winter are frequently filled with water for considerable periods.

Some discussion of their nature has been given by Prescott (1931, p. 15) who uses the results of H. N. England's work. It seems likely that the crabholes commence as cracks in the heavy clay soils and, as suggested by England, gradually form a depression surrounded by a rim somewhat above the normal level of the soil. As this rim is raised, probably as a result of clay expansion on moistening, erosive forces remove the surface and the soil of the rim exhibits subsoil characters. In the opinion of the writers the process goes further than this. During the period that standing water occurs in the depression, the soil under the rim becomes saturated and water evaporates from portions of the surface of the rim. Thus, the normal direction of the soil forming process is reversed and, instead of moisture and dissolved matters moving downwards, there is upward movement and the surface deposition of subsoil characteristics such as calcium carbonate, water soluble salts, etc., in these portions of the rim. In some instances the concentration of soluble salts on these rims becomes excessive and leads to the formation of bare, crusty or powdery patches known as crabhole puffs. This explanation is offered for the common occurrence in some districts of saline patches on the rims of crabholes in heavy country. Salt patches also occur on the level shelf areas between the crabholes (see below).

4. *Surface Concentrations Associated with Special Physical Characteristics of the Soil.*

Under dry farming conditions in the drier portions of the wheat belt of Western Australia, surface accumulations of soluble salts have been observed in cleared country, particularly on certain soil types, where the surface shows no abnormal irregularities in micro-relief and where no evidence of a water table exists. The soil types most commonly affected have generally a powdery or snuffy structure when dry and are characterised by morrel (*Eucalyptus longicornis*) and associated timbers in the virgin state. The profile consists of a brownish to greyish, calcareous, powdery loam or sandy loam on a light structureless clay or clay loam rich in calcium carbonate. Capillarity is particularly active in these soils and moisture penetration is often somewhat restricted. It is thought that capillary connection between the surface and subsoil is established after soaking rains and this connection becomes more or less permanent in patches. Where the subsoil is saline, surface accumulation of salt occurs in these patches, and this promotes the maintenance of capillary connection by virtue of affinity of the salts for water as suggested by Muntz and Gaudichon (see McCool and Wheeting (1917)).

5. *Surface Concentrations on Areas with Saline Subsoils but without unusual Micro-relief or Structure.*

To a more limited extent similar patches of salt accumulation occur in cleared salmon gum (*Eucalyptus salmonophloia*) country in which the normal soil is typically a brown to reddish brown sandy loam to sandy clay loam on a calcareous sandy clay subsoil whose structure usually shows the normal aggregations. Where surface accumulation of salt occurs, however, the soil structure on the surface breaks down and the patches are indicated by flat areas contrasting with the normal, cloddy surface soils. This effect of salts on the stability of soil aggregates has been discussed by Russell (1932). In salmon gum country occurrences of patches of saline soil are commonly contiguous to areas of light sandy soils at higher levels and it is thought that in these instances a certain amount of seepage from the light soils may be one factor in the formation of these patches.

However, similar saline patches may be observed on the level shelf areas between crabholes as mentioned above and also on areas where there is no possibility of seepage from higher land. As these soils are fairly heavy in texture and

FIGURE 1A.

Diagram showing the distribution of salt in a cleared portion of the Campion calcareous sandy loam (morrel soil) at Welbungin which has become affected by salt accumulation in patches.

B signifies bare area.
G signifies grassy or good area.

FIGURE 1B-1C.

Diagram showing the distribution of salt in cleared soils which have become affected by salt accumulation in patches.

B signifies bare area.
G signifies grassy or good area.

On Figure 1B—
CVs signifies Circle Valley sand.
CVsl signifies Circle Valley sandy loam.
Bsl signifies Beete calcareous sandy loam.

the subsoils rich in sodium and magnesium in the clay absorbing complex, restricted percolation may be a factor in promoting the formation of these saline patches by the action of capillarity. Their occurrence is a fact, however, whatever the explanation, and the concentration is undoubtedly due to capillarity.

The vertical and horizontal distribution of salt in areas in which these patches of saline soils occur in the absence of a shallow water table, seepage or special micro-relief is shown in Figure 1. Figure 1A shows the salt distribution in a

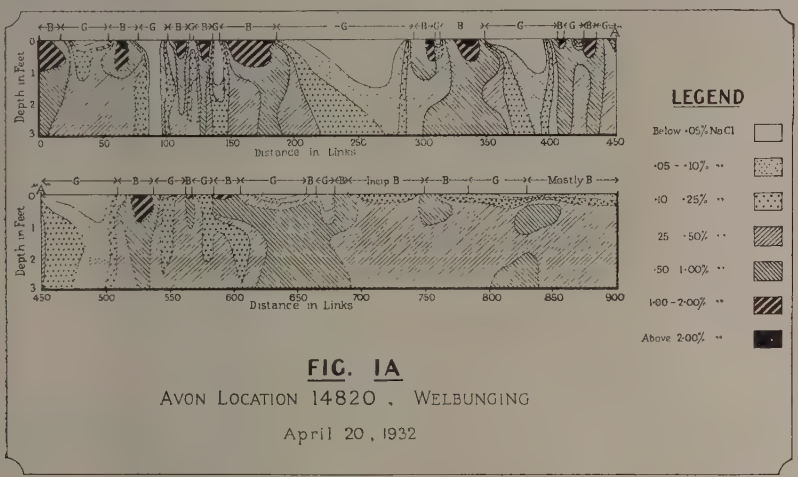


FIG. 1A

AVON LOCATION 14820 . WELBUNGING

April 20, 1932

morrel soil of a powdery structure, the Campion calcareous sandy loam, at Welbungin; Figure 1B shows the salt distribution in a complex of the Beete calcareous sandy loam, the Circle Valley sandy loam and the Circle Valley sand at

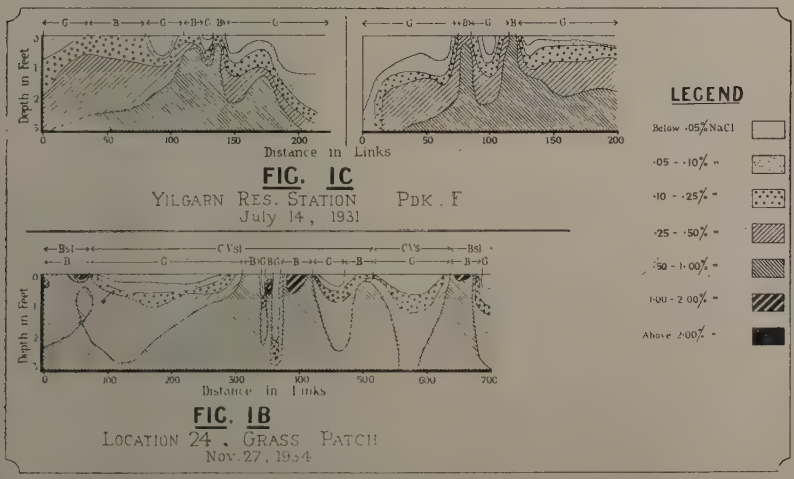


FIG. 1C

YILGARN RES. STATION PDK. F

July 14, 1931

FIG. 1B

LOCATION 24 . GRASS PATCH

Nov. 27, 1934

Grass Patch: fig. 1C, the distribution in a salmon gum type on the Yilgarn Research Station at Ghooli. The Beete calcareous sandy loam resembles the Campion calcareous sandy loam, and the Circle Valley types consist of a sandy

surface on a calcareous sandy clay loam. Where the sand is shallow—less than three inches deep—the surface and subsoil are mixed during cultural operations, producing a sandy loam surface texture. This type has been mapped as the Circle Valley sandy loam to distinguish it from types in which the surface sand is deeper.

The diagrams in Figure 1 have been constructed from the results of analyses of soil samples taken at short intervals along lines several chains long through cleared country showing saline bare patches. Generally the surface inch, and the first, second and third foot layers in the profile were sampled at sites representing the soil conditions with respect to structure, growth of grass and obvious salt accumulation.

For Figure 1A the data were obtained on 20th April, 1932, in an area of Campion calcareous sandy loam on Avon Location 14820 near Welbungin. A recent rain had caused the barley grass (*Hordeum murinum*) to germinate and areas showing a growth of these seedlings or a covering of dry barley grass from the previous season are mapped as "grassed" and indicated by the letter G. Bare and crusted areas are indicated by the letter B. Some 48 sites were sampled and 191 samples analysed in the course of this examination and enable a detailed picture to be drawn.

The data for Figures 1B and 1C were obtained in a similar manner. At Grass Patch (Figure 1B) the sampling was made on 27th November, 1934, and at the Yilgarn Research Station (Figure 1C) on 14th July, 1931.

Study of the diagrams shows clearly the wicklike action involved in the movements of the water soluble salts, and demonstrates the occurrence of contiguous vertical columns of saline and non-saline soils. Apparently the conditions following clearing cause the movement downward to take place at one spot while an upward movement with surface accumulation is observed adjacent in certain soil types. In other soil types, *e.g.*, Circle Valley sand, only the downward movement is observed. Just how permanent these patches are under these field conditions has not been determined.

Sampling of virgin country in the same localities shows that prior to clearing a fairly uniform distribution occurs with the surface foot averaging about 0.15 per cent. salt (NaCl), the second foot 0.30 per cent. salt and the third foot 0.40 per cent. salt. The redistribution follows naturally after clearing, especially in the heavier and more powdery, calcareous soil types. It is independent of a shallow water table, as in none of these instances was a water table present within many feet of the surface, and appears to occur within the soil mass to a depth of several feet, probably 5 or 6 feet.

Figure 2 gives additional details concerning one of the bare patches encountered on the line in Figure 1A. The samplings were made as closely as possible to the edge of the barley grass which had grown the previous season (in 1931). These "edge" sites are generally high in salt and would suggest that the area of surface salt accumulation was expanding somewhat.

B.—THE EFFECT OF CLEARING THE NATURAL VEGETATION ON THE MOVEMENT OF SOLUBLE SALTS IN THE SOIL UNDER AN 11 TO 16 INCH RAINFALL.

The discovery that certain soil types in outlying portions of the wheat belt of Western Australia were more or less affected with excessive quantities of soluble salts led to comprehensive soil surveys and reconnaissance surveys in the districts in question. In interpreting the results of the soil analyses it was possible to

FIGURE 2.

Plan of a saline bare patch in Campion calcareous sandy loam (grey, snuffy morrel country) on Avon Location 14820, Welbungin, showing the composition of marginal sites and the central portion. The dead barley grass of the previous season (1931) delineates the boundary of the bare patch. The depths are given in inches and the analyses as per cent. sodium chloride calculated from total chloride.

draw on the experience of farmers in Western Australia and on the information contained in an extensive literature on saline or alkali soils.

All of the practical and scientific evidence led to the conclusion that, under dry farming conditions, where the rainfall ranges from 11 to 14 inches per annum, soils affected with salt in the virgin state must be regarded with suspicion and as more or less unsuitable for wheat production. In the Salmon Gums district, certain soil types which had yielded 15 bushels of wheat per acre at the first crop produced about one-third the crop subsequently, and the failure was directly correlated with soil salinity. At Lake Brown, Newdegate and other centres supporting evidence was available, and it may be asserted that the general conclusion still stands.

The preliminary investigation of cleared and virgin forest country at Lake Brown, which is principally of the medium to heavy textured types, disclosed no

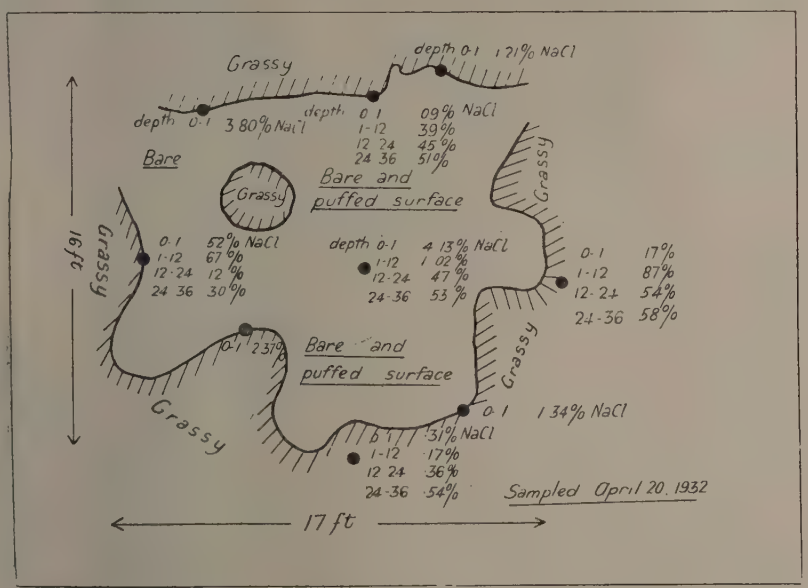


Fig. 2.

evidence of the substantial leaching of salt following clearing. Changes did occur but involved redistributions similar to those described above.

In carrying out the detailed soil alkali survey, however, the soil type was recognised as the unit in classification and the distribution of salt superimposed on the soil type map. This led to the discovery early in the survey at Salmon Gums that certain of the saline soil types varied from the general rule after clearing. It was found that well-drained, sandy-surfaced soil types were readily leached of soluble salts following clearing, but the heavier-textured types, where affected by salt concentration before clearing, failed to exhibit such improvement and generally developed patches showing surface salt accumulation as described above.

To determine the changes in salt status, following clearing over large areas, a study was subsequently made of the analyses of samples from thousands of sites, taken both in cleared and virgin country, in the Salmon Gums area, where the average annual rainfall ranges from 12 inches in the north to 16 inches in the south.

Table 2 represents the incidence of salt at apparently normal sites in virgin and cleared land, taking four distinct groups of soils as representatives of the area. It is seen that, in the virgin state, all groups of soil show a considerable proportion of sites at which the salt (NaCl) content of the surface two feet exceeds 0.22 per cent. This may be taken as the limit below which growth of wheat should not be seriously affected.

TABLE 2.

Effect of Clearing on the Salinity of Soils of various Types in the Salmon Gums Area.

All analyses considered in this table are for "normal" sites; that is, sites not showing surface evidence of salt accumulation.

GROUP A.—Sandy surfaced soils (with sandy clay subsoils) include the Circle Valley sand and Scaddan sand.

GROUP B.—Medium textured soils include the Kumarl sandy loam and the Circle Valley sandy loam.

GROUP C.—Highly calcareous soils—the Beete calcareous sandy loam.

GROUP D.—Heavy textured soils include the Kumarl clay loam and the Dowak clay loam.

Analyses as per cent. Salt (NaCl) in the Oven Dry Soil.

Group.	Condition.	Total Number of Sites.	Percentage of sites within each Range of Salt (NaCl) concentration in the Soil to a depth of two feet.				
			Below 0·13. %	0·13 to 0·17. %	0·18 to 0·22. %	0·23 to 0·29. %	above 0·30. %
A.	Virgin	4,324	17·6	14·9	20·2	25·2	22·1
	Cleared	4,255	78·2	13·0	5·7	1·9	1·2
B.	Virgin	1,901	8·6	8·7	15·3	23·4	44·0
	Cleared	1,998	45·9	16·2	14·2	11·2	12·5
C.	Virgin	1,950	10·0	8·0	12·7	18·6	50·7
	Cleared	491	42·6	14·2	11·6	9·0	22·6
D.	Virgin	1,237	7·0	6·3	8·5	15·6	62·6
	Cleared	837	17·1	14·7	15·0	15·8	37·4

Of most importance is the distribution of sites according to salt status after the land has been cleared for some years.

The sandy-surfaced types show practically complete removal of deleterious quantities of salt in the surface two feet and, furthermore, as shown in Table 3, a negligible amount of surface accumulation in the form of bare patches occurs. Bare patches associated with salt accumulation are very rarely seen on this group of soils.

A very considerable improvement has taken place in the medium-textured soils represented by the Circle Valley sandy loam and the Kumarl sandy loam (Group B), but still about one quarter of the "normal" sites sampled on cleared country show above 0.22 per cent. salt in the surface two feet. In addition, surface accumulation of salt in bare patches occurs to a certain extent in the types in this group (Table 3), so that recovery may be estimated at about 60 per cent. in the areas affected by high concentrations of salt in the virgin state.

TABLE 3.

Number Sampled and Analyses of Bare Patches suspected of being due to Salt Accumulation in the Principal Soil Types of the Salmon Gums Soil Survey.

Sites in Cleared and Virgin country are segregated for purposes of comparison.

Analyses as per cent Salt (NaCl) in the Oven Dry Soil. Sampling depth is 12 inches.

Soil Type.	Condition.	Total Number of of bare patches sampled.	Percentage of samples from bare patches within each range of Salt (NaCl) concentration to a depth of one foot.					Total Number of sites sampled, including bare patches.	Bare patches as percentage of total sites sampled.
			Below 0.11.	0.11–0.24.	0.25–0.49.	0.50–1.00.	Above 1.00.		
			%	%	%	%	%		
Circle Valley Sand (shallow phase) (Group A)	Virgin ...	3	33	...	...	67	...	2799	0.1
	Cleared ...	24	21	21	21	37	...	2958	0.8
Circle Valley Sandy Loam (Group B)	Virgin ...	5	40	40	...	20	...	993	0.5
	Cleared ...	146	13	22	32	30	3	1638	8.9
Beete Calcareous Sandy Loam (Group C)	Virgin ...	19	5	26	21	27	21	1969	1.0
	Cleared ...	96	5	10	29	45	11	587	16.4
Kumarl-Dowak Clay Loam (Group D)	Virgin ...	24	17	12	8	25	38	1261	1.9
	Cleared ...	166	1	6	30	55	8	1003	16.5

The calcareous-surfaced soils of Group C, as represented by the Beete calcareous sandy loam, resemble somewhat the other sandy loam types of Group B as far as salt distribution in the virgin state is concerned. Improvement after clearing has taken place in the "normal" sites as shown by Table 2 but still over 30 per cent. of the samples fall in the high group (above 0.22 per cent. salt in the surface two feet) as compared with 69 per cent. in the virgin soils. In addition, considerable development of bare patches showing surface accumulation of salt has taken place in this type and from Table 3 it is seen that most of these bare patches are very high in salt. This is probably due to the superior capillary properties of the soils of this group. As field observations suggest that in this soil type the bare patches are even more important than is indicated by the proportion of bare patches sampled, and normal sites retain a considerable proportion of salt, areas of this type where saline in the virgin state must still be regarded as subject to serious reduction in value for wheat production if brought under cultivation. Recovery following clearing may be estimated at less than 50 per cent. Furthermore, the Beete calcareous sandy loam, known locally as "Kopi" soil in the Salmon Gums district, is found to be unsatisfactory for wheat-growing under low rainfall conditions, even where free of salt, and must be regarded as an unsatisfactory type generally for development for wheat-farming.

The heavy-textured soils of Group D, including the Kumarl clay loam and the Dowak clay loam, are by far the most saline soils in the virgin state and from the evidence available show an inconsiderable improvement (probably not more than 25 to 30 per cent.) in normal sites after clearing. Furthermore, these types, and more particularly the Dowak clay loam, are very subject to the development of bare patches, showing, as indicated in Table 3, considerable salt accumulation. Development of saline bare patches has even occurred to a small extent under virgin conditions in this group.

Surface accumulation of salt in these types of this group has occurred both on the rims of crabholes and on the areas showing no evidence of micro-relief. In many instances, the incidence of bare patches alone seriously reduces the yield of wheat crops. This reduction is difficult to estimate, as the proportion of bare patches sampled is only a slight index of their relative abundance in cleared country. The soils of this group have proved generally unsatisfactory for wheat-growing for a number of reasons, of which soil salinity is one of the most important. Fortunately, investigations at the Salmon Gums Research Station indicate that Wimmera Rye Grass and certain salt bushes of high salt tolerance may do much toward the profitable utilisation of these soils and may even promote more substantial reclamation. (Teakle (1937).)

Leaching of Salt following clearing of the Circle Valley Sand.

The question of the leaching of the soluble salts was investigated in greater detail in selected sites in the Circle Valley sand. In the first place clearing lines in a uniform area of the type were selected in two places on location 588, East Dowak, and series of samples taken along lines 3 chains apart:—

(a) 1½ chains within the virgin timber;

(b) 1½ chains within the clearing.

The results are given in Table 4 and are characteristic of other investigations of a similar nature on this soil type. There is no doubt that general and substantial leaching of water soluble salts has occurred following clearing.

In the second place, pairs of type samples to a depth of 15 to 20 feet were obtained from sites in virgin and cleared Circle Valley sand on Fitzgerald location

588, East Dowak, and Fitzgerald Location 422, East Circle Valley. The sites in virgin country were one to one and a half chains within the undisturbed timber and the sites in cleared country directly opposite and a similar distance from the edge of the clearing. The soil profiles were as similar as could be expected in both pairs of sites. On Fitzgerald Location 588 the land had been cleared two years and on Fitzgerald location 422, five years.

TABLE 4.

Salt (sodium chloride) content of samples from adjacent virgin and cleared areas of the Circle Valley sand on Fitzgerald Loc. 588, East Dowak. Each figure is the average of several samples and the percentage is calculated to the oven-dry soil basis.

Series.	Condition of Country.	Number of Sites.	Per cent. Salt with Depth in Oven-dry Soil.				
			Surface Sand.		Sandy Clay Loam to Sandy Clay.		
			0in.—1in.	1in.—3in.	3in.—12in.	12in.—18in.	18in.—24in.
I.	Virgin	6	0·003 (·002—·005)	0·009 (·003—·023)	0·232 (·110—·387)	0·373 (·245—·453)	0·437 (·343—·520)
	Cleared	6	0·003 (·000—·008)	0·008 (·002—·020)	0·017 (·008—·042)	0·039 (·012—·088)	0·070 (·035—·130)
II.	Virgin	7	0·02		0·16 (·06—·24)	0·39 (0·27—·53)	
	Cleared	7	0·02		0·04 (0·01—0·10)	0·11 (·01—·27)	

The vertical distribution of the salt in the profiles is represented in Figure 3 and shows that considerable displacement downwards has followed the clearing of the land. While the possibility of soil variability being an important factor in leading to this difference must be considered, a great deal of collateral evidence obtained in the course of the soil survey indicates that the observed difference is at least largely the result of leaching following clearing.

Some measure of the original degree of similarity of the sites of each pair may be gauged from a consideration of the total salt contents of the profiles. Assuming that an acre foot of soil weighs 1,560 tons the amounts of salt in each profile in tons per acre to the depth specified are as follows:—

Fitzgerald Location 588 (19 feet deep).		Fitzgerald Location 422 (15 feet deep).	
Virgin— 173 tons	Cleared— 167 tons	Virgin— 129 tons	Cleared— 112 tons

When the natural variability of soils is considered it can be concluded that the sites in each pair were closely similar prior to clearing.

If it be assumed that the sites of each pair were identical prior to clearing it may be observed from Figure 3 that displacement has occurred to a depth of 3½ feet on Fitzgerald location 588 (in the course of two years) and to a depth of 6 feet on Fitzgerald location 422. On the same assumption this displacement is reflected

by an approximately equivalent concentration in the substratum on Fitzgerald location 588. On Fitzgerald location 422 the evidence for the concentration in the substratum is inconsequential and study of the salt profiles suggests that originally the

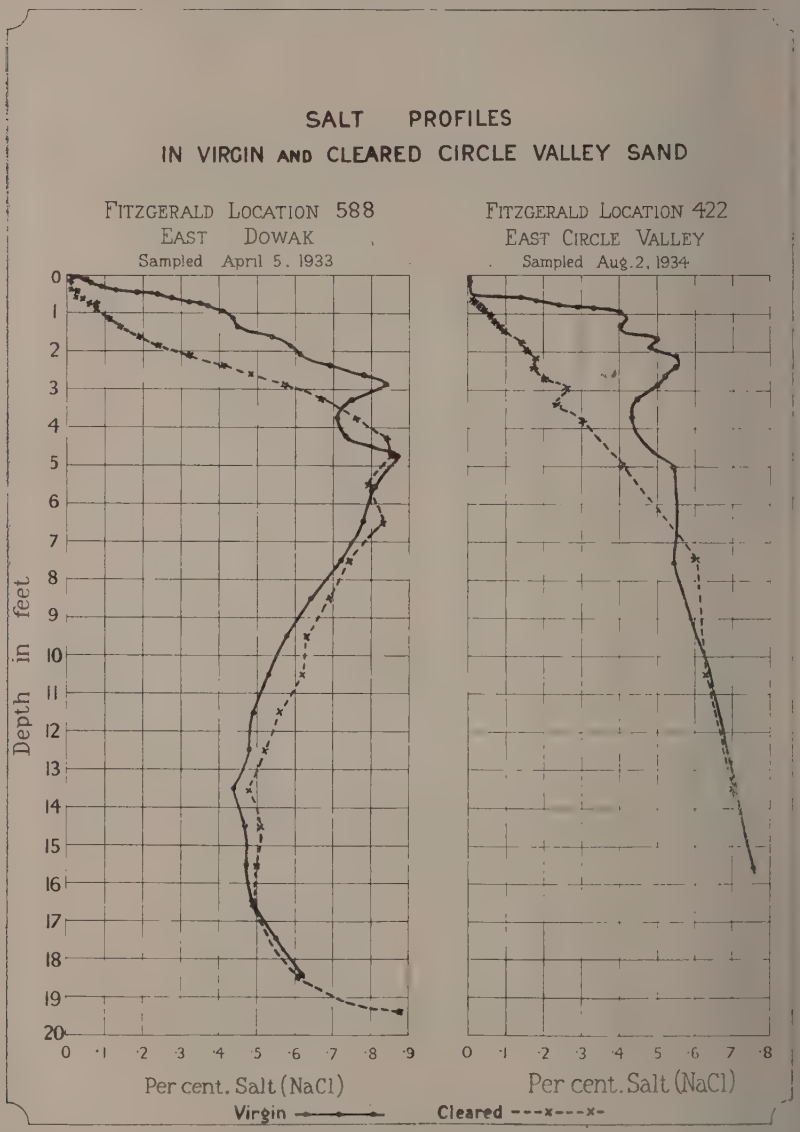

SALT PROFILES
IN VIRGIN AND CLEARED CIRCLE VALLEY SAND
FITZGERALD LOCATION 588
EAST DOWAK
Sampled April 5, 1933
FITZGERALD LOCATION 422
EAST CIRCLE VALLEY
Sampled Aug. 2, 1934
Depth in feet
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
0 ·1 ·2 ·3 ·4 ·5 ·6 ·7 ·8 ·9
Per cent. Salt (NaCl)
0 ·1 ·2 ·3 ·4 ·5 ·6 7 ·8
Per cent. Salt (NaCl)
Virgin
Cleared

Fig. 3.

site now in cleared country was 10 to 15 per cent. less saline than its pair. The assumed "losses" and "gains" in the various portions of the profiles are given in Table 5. Also, by way of comparison it is assumed that the site in cleared country

FIGURE 3.

The salt profiles of the Circle Valley sand on Fitzgerald location 588 at Ea
Dowak and Fitzgerald location 422 at East Circle Valley. The sites sampled on ea
location were in virgin and cleared country and were about 3 chains apart. Stu
of the figures suggests that the salt profiles before clearing were closely similar b
movement downwards has occurred since the removal of the timber about 2 to 5 yea
prior to sampling. The crosses and dots indicate the centres of the layers sampled.

on Fitzgerald location 422 originally contained 13 per cent. less salt uniformly throughout the profile than its pair. The figures from this computation are included in Table 5.

TABLE 5.

Apparent displacement of Salt (NaCl from Cl) in the profiles of adjacent cleared and virgin sites in the Circle Valley sand on Fitzgerald Locations 588 and 422.

Fitzgerald Location 588 (Cleared 2 years).			Fitzgerald Location 422 (Cleared 5 years).			
Depth of Zone (feet).	Assumed gain or loss of salt in the cleared soil in terms of tons per acre.		Depth of Zone (feet).	Assumed gain or loss of salt in the cleared soil in terms of tons per acre.		Assumed gain or loss of salt in the cleared soil if the salt concentration were originally 13 per cent. less than in the present virgin site—in terms of tons per acre.
	gain.	loss.		gain.	loss.	gain.	loss.
0 —3½	...	13 tons	0 — 6	...	19·5 tons	...	14·0 tons
3½—4½	1·2 tons	...	6 — 9	2·7 tons	...	6·1 tons	...
4½—6	...	0·5 tons	...	...	...	...	...
6 —16	7·5 tons	...	9 — 15	...	0·5 tons	7·9 tons	...
Error	4·8 tons		...	17·3 tons		...	

There is no doubt that substantial leaching of salt has taken place in the Circle Valley sand and the quantity removed from the upper portions of the subsoil amounts to 10 to 20 tons per acre. This would be about half of the content in the virgin state and the loss is incurred in a surprisingly short period of years.

Moisture determinations were made on the samples from Fitzgerald Location 422 with the results as given in Table 6.

TABLE 6.

Moisture Content of Soils from sites in virgin and cleared Circle Valley Sand on Fitzgerald Location 422. Sampled 2nd August, 1934.

Depth.	Virgin.	Cleared.
Inches.	Moisture %.	Moisture %.
0—6	1·8	8·1
6—12	10·3	14·2
12—24	12·7	15·9
24—36	13·5	17·2
36—48	12·4	14·9
Feet.		
4—6	14·7	15·7
6—9	15·1	17·1
9—12	17·1	16·3
12—15	17·2	16·7
15—16½	19·7	...

The deeper subsoil layers in the virgin soil were distinctly moist but in the cleared area the moisture was apparent below the first foot. The relation between these moisture contents and such constants as the moisture equivalent or sticky point has not yet been determined.

The effect of leaching on the composition of the water soluble salts.

The composition of the water soluble fraction changes significantly in the course of the leaching following clearing in any soil type subject to the process. This was shown primarily by the relation between electrical resistance of the soil suspension and chloride content. This ratio is wider in the leached soils and indicates the greater mobility of chloride as compared with other ions. From the results of chemical examination of the water soluble fraction, it appears that bicarbonate takes the place of the chloride removed in excess of cations.

The relation between chloride and specific resistance in virgin and cleared soils is indicated in Table 7, and in Table 8 is shown the chemical composition of the

TABLE 7.

The relation between the specific resistance of the 1 : 5 soil : water suspension and salt content of a large number of sites in virgin and cleared country at East Dowak, 22nd May to 11th September, 1933. (Salt content is calculated from chloride.)

Specific Resistance (ohms at 60° F.)	Salt content (per cent. NaCl in oven-dry soil) Virgin Sites.	Cleared Sites.
700	0·35	0·34
750	0·32	0·31
800	0·30	0·28
850	0·28	0·25
900	0·26	0·23
950	0·25	0·21
1000	0·23	0·20
1100	0·21	0·18
1200	0·19	0·16
1300	0·17	0·14
1400	0·16	0·12
1600	0·13	0·10
1800	0·11	0·08
2000	0·10	0·07
2200	0·09	0·06
2400	0·08	0·05
2600	0·07	0·04

water soluble salts in virgin and cleared soils using the samples from the sites in the Circle Valley sand types discussed above. Figure 4 graphically illustrates the changed relation between total water soluble salts and salt in the leached layers. In Table 9 is shown the relation between the ions determined in the water soluble salts and reported in Table 8.

It should be pointed out that calcareous nodules and soft calcium carbonate also occur in these profiles from about 6 to 9 inches to 5 feet deep (9 feet in the case of Location 442). The deeper layers are not only non-calcareous, but are strongly acid in reaction.

On account of their very low soluble salt content no data are presented for the surface sands. The sand layer was four inches deep in the profiles from Fitzgerald Location 588 and 6 to 7 inches deep from Fitzgerald Location 442. On account of the very low chloride content of the clay immediately below the sand in the cleared site on Location 422, this layer was not examined for the composition of the water soluble salts.

First, to consider the results from the work on Fitzgerald Location 588, from Table 9 it is seen that the ratio of bicarbonate to chloride in the subsoil to a depth of 3 feet in the cleared soil is from 5 to 8 times that for the same layers in the virgin soil and similarly the ratio of bicarbonate to sodium and to total water soluble salts has considerably increased following clearing—1½ to nearly 3 fold.

If, as seems reasonable, it be assumed that the 4-17 inch layer in the virgin soil and the 4-13 inch layer in the cleared soil were originally comparable, the proportion of chloride in the total water soluble salts has dropped from an average of 32.7 per cent. in the virgin soil to 10.8 per cent. in the cleared land, while the proportion of bicarbonate has increased from 25.8 per cent. to 49 per cent. Sodium appears to move slightly faster than the total water soluble salts as the proportion in the total water soluble salts has decreased from 31.4 per cent. in the virgin soil to 28.2 per cent. in the cleared soil. The proportion of sulphate shows a significant decrease in the cleared soil in this case.

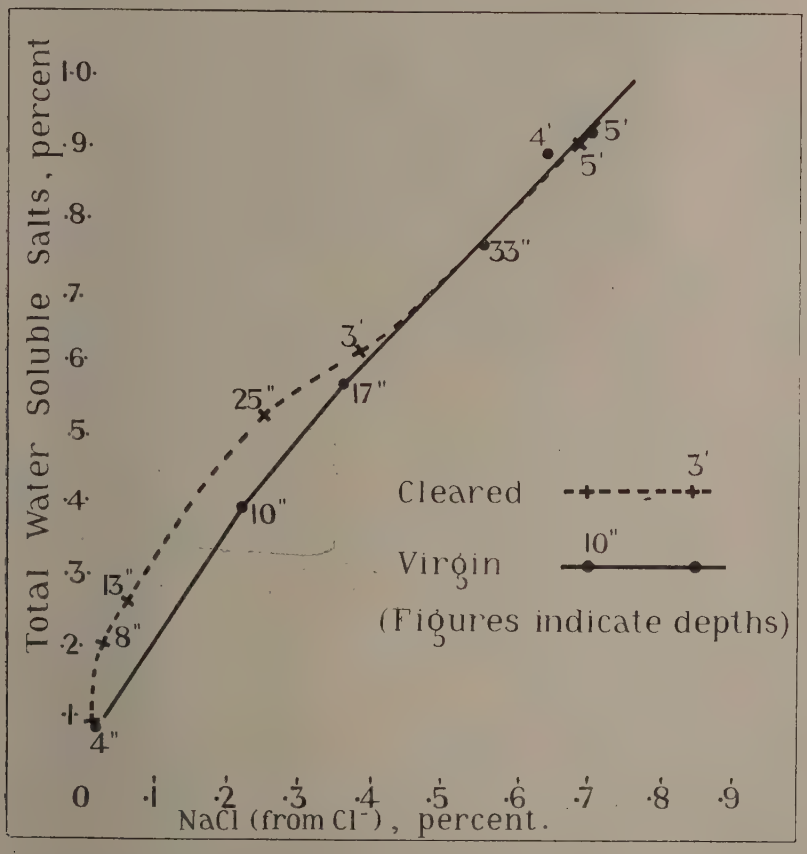


FIGURE 4.

Graph showing relation between Total Water Soluble Salts and salt (NaCl calculated from chloride) in virgin and cleared Circle Valley sand as represented by the type samples on Fitzgerald location 588.

In patches where surface accumulation of soluble salts occurs, a reversal of the above relationships is indicated for chloride, as conductivity and chloride titration determinations show an increased percentage of chloride in the water soluble salt fraction. Apparently the chloride ion is the most mobile in the soil and the property is expressed whether the movement be upwards or downwards.

TABLE 8.

The constituents of the Water Soluble Salts of Virgin and Cleared Soils of the Circle Valley sand type.

Results expressed as per cent. of the oven-dry soil.

Serial Number.	Depth.	T.W.S.S.*	Sodium. Na.	Potassium K.	Magnesium Mg.	Calcium Ca.	Sulphate SO_4.	Nitrate NO_3.	Carbonate CO_3.	Bicarbonate HCO_3.	Chloride Cl.
	inches.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
A.– Samples from Fitzgerald Location 588.											
Virgin Soil—											
853	4 to 10	·456	·130	·006	·003	·002	·028	·005	....	·149	·133
854	10 ,, 17	·602	·206	·007	·003	·002	·049	·004	....	·113	·218
855	17 ,, 33	·832	·324	·008	·005	·003	·076	·006	....	·075	·335
Cleared Soil—											
866	4 ,, 8	·196	·052	·009	·002	·003	·008	·005	....	·098	·019
867	8 ,, 13	·331	·099	·007	·001	·002	·015	·009	....	·159	·039
868	13 ,, 25	·517	·155	·007	·001	·002	·043	·007	....	·151	·151
869	25 ,, 36	·649	·246	·011	·002	·003	·076	·006	....	·073	·232
B.—Samples from Fitzgerald Location 422.											
Virgin Soil—											
1117	12 to 24	·625	·220	·007	·003	·008	·043	·003	·006	·066	·269
1118	24 ,, 36	·669	·237	·006	·004	·005	·053	·001	·005	·063	·295
1121	72 ,, 108	·699	·250	·006	·003	·003	·059	·002	·004	·050	·322
1123	144 ,, 180	·792	·282	·008	·005	·002	·070	·002	*Nil*	·006	·417
Cleared Soil—											
1127	13 ,, 25	·342	·108	·002	·001	·002	·022	·003	·024	·106	·074
1128	25 ,, 37	·452	·135	·011	·002	·002	·039	·002	·005	·131	·125
1131	72 ,, 108	·768	·247	·011	·005	·008	·073	·002	*Nil*	·062	·360
1133	144 ,, 180	·764	·257	·014	·008	·001	·062	Tr.	*Nil*	·002	·420
Sea Water	....	3·48	1·03	·06	·13	·05	·28				1·90

Analyst—F. F. ALLSOP.

* Total water soluble salts (T.W.S.S.) is obtained in this instance by addition of the ions determined by analysis as CO_2 is lost in the determination of T.W.S.S. by the usual gravimetric method.

TABLE 9.

Relation between Constituents of the Water Soluble Salts of Virgin and Cleared Sites in the Circle Valley Sand from information reported in Table 7.

Ratios expressed as per cent.

Serial Number.		Na.	Cl.	HCO_3. †	SO_4.	Cl.*	HCO_3.†	HCO_3.†	T.W.S.S., per cent. dry soil.
	Depth (inches).	T.W.S.S., per cent.	T.W.S.S., per cent.	T.W.S.S., per cent.	T.W.S.S., per cent.	Na, per cent.	Na, per cent.	Cl, per cent.	
			A.—Samples from Fitzgerald Location 588.						
Virgin Soil—									
853	4—10	28·5	29·2	32·8	6·1	102	115	112	·456
854	10—17	34·2	36·2	18·8	8·1	106	54·9	51·8	·602
855	17—33	38·9	40·3	9·0	9·1	103	23·1	22·4	·832
Cleared Soil									
866	4—8	26·5	9·7	50·0	4·1	36·6	188	516	·196
867	8—13	29·9	11·8	48·0	4·3	39·4	161	408	·331
868	13—25	30·0	29·4	29·4	8·3	97·4	97·4	100	·517
869	25—36	37·9	35·8	11·2	11·7	94·3	29·7	31·4	·649
			B.—Samples from Fitzgerald Location 422.						
Virgin Soil—									
1117	12—24	35·2	43·1	12·5	6·9	122	35·5	29·0	·625
1118	24—36	35·4	44·1	10·9	7·9	125	30·8	24·4	·669
1121	72—108	35·8	46·1	8·3	8·4	129	23·2	18·0	·699
1123	144—180	35·6	52·7	0·8	8·8	148	2·1	1·4	·792
Cleared Soil—									
1127	13—25	31·6	21·6	45·3	6·4	68·5	144	210	·342
1128	25—37	29·9	27·7	31·2	8·6	93	104	113	·452
1131	72—108	32·2	46·9	8·1	9·5	146	25·1	17·2	·768
1133	144—180	33·6	55·0	0·3	8·1	164	0·8	0·5	·764
Sea Water	...	29·6	54·6	?	8·0	184	?	?	3·48

* Ratio Cl to Na in common salt (NaCl) = 154 per cent.

† CO_3 is converted to an equivalent weight of HCO_3 by multiplying by 2·03 and added to the HCO_3 determined.

The evidence from Fitzgerald Location 422 supports the above conclusions and serves to amplify that from Fitzgerald Location 588 on account of the examination of samples from deeper layers—and into the strongly acid substrata below 12 feet deep.

As discovered for the sites from Location 588, throughout the profile calcium and magnesium are quite low but potassium seems very well supplied in the water soluble form. In the deep layers from the sites on Location 422 sodium and chloride approach molecular proportions and, as would be expected from the acidity, bicarbonate is almost non-existent.

In comparison with the salts of sea water, these soil salts contain a somewhat lower proportion of potassium, and the calcium ratio and the magnesium ratio are considerably lower. The proportion of sodium is somewhat greater and that of chloride is generally lower in the surface but closely approaches the proportion of sea salt in the deeper layers. The proportion of sulphate is approximately the same as in sea water in 3 of the 4 sites. In spite of the divergences, it can well be, however, that these salts are of marine origin, probably derived from the rainfall, and have been slightly modified in composition by reaction with the soil. For instance, the high proportion of replaceable magnesium in these soils may be partly the result of reaction between the soil and the cyclic salts.

The two maxima shown in the graph (Fig. 3) of the salt profiles are of considerable interest and represent a very common feature of salt profiles in the Salmon Gums area. This matter will be discussed in a later paper but it may be mentioned that in the case of the samples from Fitzgerald Location 588 in the virgin profile, the subsoil was visibly moist below 33 inches, the depth of the first maximum. In the cleared profile the soil was moist from 8 inches deep. The layer between one and three feet deep was wet and sticky to the feel, and the deep subsoil (below 5 feet) appeared slightly more moist than in the virgin profile. This observation correlates with a higher salt content in the deep subsoil of the cleared profile but, unfortunately, no facilities for moisture estimations were available at the time and precise data cannot be given. The information from Fitzgerald Location 422 does not appear to offer any clarification of the phenomenon.

C. MOVEMENT OF SALT IN TANKS AT THE MERREDIN RESEARCH STATION.

While the field data provide convincing evidence of the rapid leaching of water soluble salts in sandy surfaced soils after clearing under relatively low rainfall conditions (11 to 16 inches per annum) and of substantial improvement in medium textured soils of the sandy loam class the evidence from tank experiments under controlled conditions was studied as a check.

On 30th and 31st March, 1931, four tanks, each about 6 feet deep and 3 to 4 feet in diameter, were filled with sandy clay loam soil typical of the surface 9 inches of the soil of the Merredin Research Station.

The soil was tightly packed into the tanks when in an air dry condition and in three of the tanks three-inch layers consisting of commercial calcium chloride mixed with about 6 parts of soil were interposed. The object of the experiment was the determination of the effect of the natural rainfall on the movement of the chloride in the soils under the conditions of the wheatbelt. The annual rainfall at the Merredin township averages 13.24 inches.

At the outset the condition in the tanks was as follows:—

Tank 1. Control; no calcium chloride.
Tank 2. Calcium chloride—soil mixture at 3-6 inches from the surface.
Tank 3. Calcium chloride—soil mixture at 9-12 inches from the surface.
Tank 4. Calcium chloride—soil mixture at 21-24 inches from the surface.

Samples of soil taken from the heap of soil prior to filling the tanks gave the following results on analysis:—

Sample.	Moisture per cent. oven-dry Soil.	Salt (NaCl) calculated from Chloride (per cent. oven-dry Soil.)
1	8·36	0·043
2	7·71	0·038
3	7·50	0·028
4	5·50	0·018
5	5·75	0·013

The tanks were placed in the open, weeds destroyed (weeds grew on Tank No. 1 during the first winter owing to an oversight), and a shallow loose mulch about one inch deep maintained at the surface.

As the soil is of the calcium-magnesium type with respect to replaceable bases, calcium chloride, and not sodium chloride, was used as a source of chloride, because the effect of sodium salts on the soil might have been the destruction of the structure on leaching and hence the restriction of percolation. It was also realised that the soils in the tanks would not exactly simulate the natural soil conditions as temperature changes would be more marked and this would affect the loss of moisture by vaporisation. There is reason to believe, however, that the behaviour of chloride in the tank soils will closely resemble that which would be observed under field conditions.

The tanks were sampled twice per year; in August or September to show the conditions following the winter rains and in February or March after several months of hot, dry summer weather. Sampling was accomplished by means of a spatula in the surface layers to a depth of about 8 inches and in the deeper layers by means of a modified wood auger inserted into the side of the tank at the desired depth. In taking the samples with the auger the peripheral 6 inches were discarded and the material for testing taken from the soil between 6 and 18 inches of the side of the tank. Moisture, conductivity of the 1:5 soil: water suspension and chloride were determined on each sample. The distribution of salt (NaCl calculated from chloride) in the tanks is shown in Figure 5.

In studying the distribution of salt with the progress of time the factor of variability must be recognised and due caution used in arriving at conclusions. Channelling and less pervious patches in the soil mass will lead to apparent fluctuations which are of no significance.

It is clear, however, that movement of salt both upwards and downwards has taken place and, further, that the downward movement is considerably greater than the upward.

In August, 1937, six years after the commencement of the experiment the situation was as follows:—

TABLE 10.

	Tank 2*	Tank 3.	Tank 4.
Salt layer (inches)	3–6	9–12	21–24
Salt above zone of application (per cent. of total salt)	Trace	10·8	29·4
Salt at zone of application (per cent. of total salt)	Trace	2·4	8·9
Salt below zone of application (per cent. of total salt) ...	100	86·8	61·7
Salt below 24-inch depth (per cent. of total salt)	87	63·3	61·7

* A five-inch sand layer was applied to this tank on 22nd November, 1934.

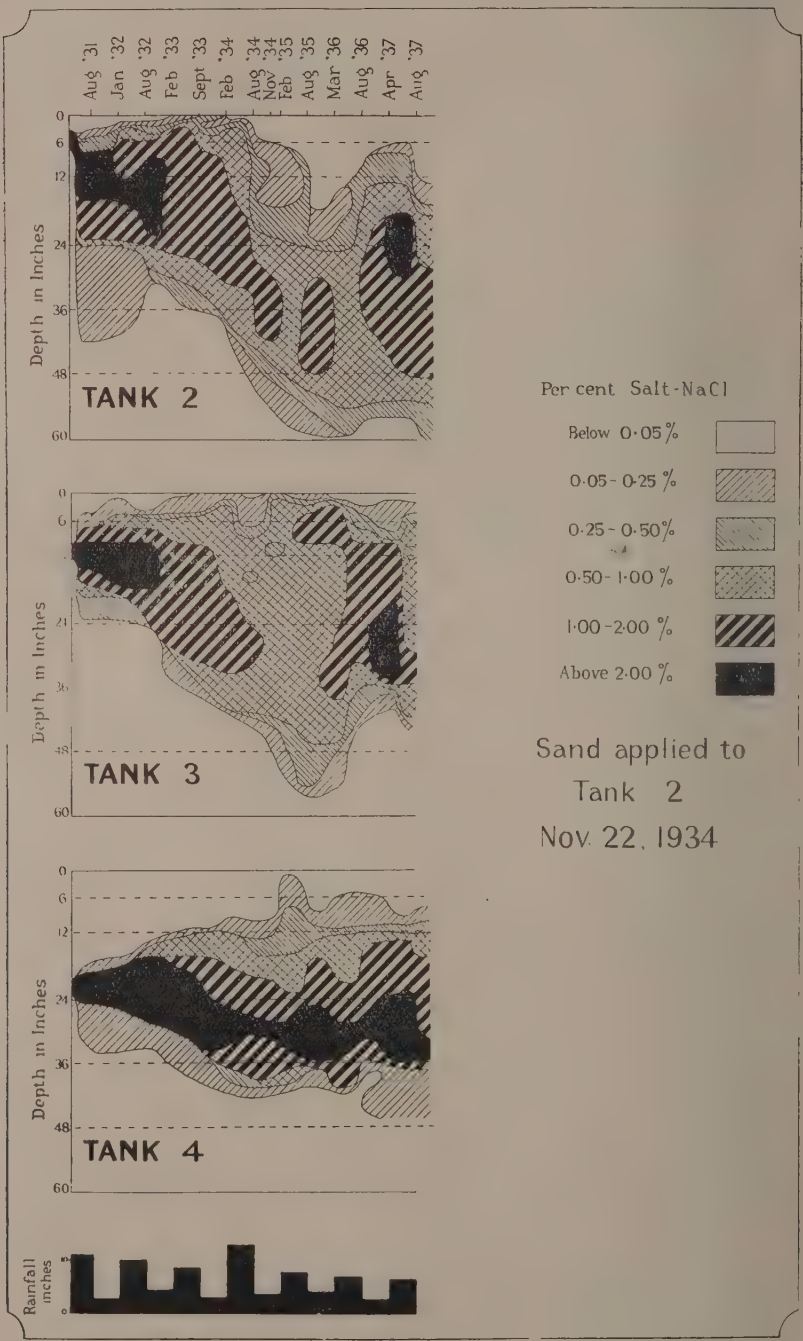

Aug '31
Jan '32
Aug '32
Feb '33
Sept '33
Feb '34
Aug '34
Nov '34
Feb '35
Aug '35
Mar '36
Aug '36
Apr '37
Aug '37
Depth in Inches
0
6
12
24
36
48
60
TANK 2
TANK 3
TANK 4
Per cent Salt-NaCl
Below 0·05 %
0·05 - 0·25 %
0·25 - 0·50 %
0·50 - 1·00 %
1·00 - 2·00 %
Above 2·00 %
Sand applied to
Tank 2
Nov. 22, 1934
Rainfall
inches

Fig. 5.

In tanks 3 and 4 approximately the same proportion, namely about two-thirds of the amount of salt in the profile, has moved below the two-feet level.

In the case of Tanks 2 and 3, by August, 1934, the salt profile in each was practically identical. This fact was taken advantage of and the top five inches of

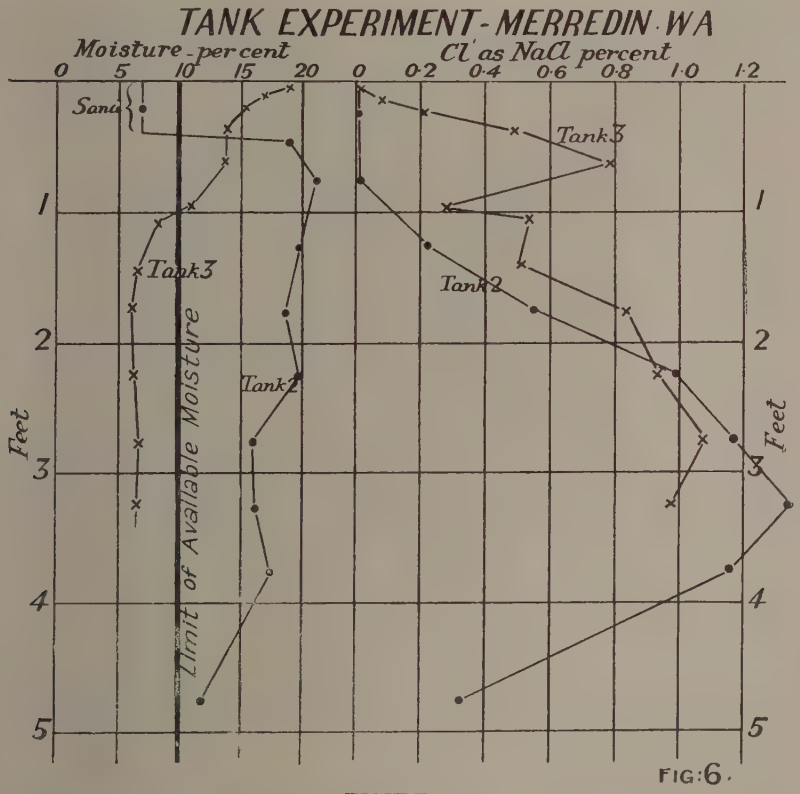


FIGURE 6.

The distribution of salt and moisture in Tank 2 (with a sandy surface) and Tank 3 on 27th August, 1937. The limit of "available" moisture is assumed to be 10 per cent.

soil in Tank 2 was removed and replaced by a like depth of loose sand on 22nd November, 1934. This profile now resembled the Circle Valley sand in textural features and it was interesting to observe that leaching of the chloride was immediately accelerated and at the occasion of the August, 1937, sampling 87 per cent. had been driven below the two-feet mark. Chloride concentration was observed at the 57-inch mark.

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*FIGURE 5.

Movement of salt in soils in tanks exposed to natural wheatbelt conditions at the Merredin Research Station. Layers of salt (using calcium chloride) were placed at varying depths in the profile and the subsequent distribution of chloride determined. A 5-inch layer of sand was placed on top of the soil in Tank 2 on 22nd November, 1934.

Tank 2. Salt layer at 3-6 inches.
Tank 3. Salt layer at 9-12 inches.
Tank 4. Salt layer at 21-24 inches.

This sandy surface was valuable in promoting moisture retention and thereby promoted the leaching of salt. Calculating the soil moisture to a depth of 45 inches in terms of inches of rainfall on August 27th, 1937, Tank 2, with the sandy surface, contained 9 inches, Tank 3, 5.2 inches and Tank 4, 4.9 inches of rain.

Burvill (1930) reports the wilting point of a sample of surface soil from the Merredin Research Station to be 11 per cent. As the soil used in these tanks would closely resemble this sample, it seems reasonable to assume that the moisture in excess of 10 per cent. of the dry soil would be available for plant growth. On this basis the "available" moisture in the tanks on 27th August, 1937, would be—

Tank 1.	... ...	0·40 inches "available" water.
Tank 2.	(Sandy surface) ...	4·38 inches "available" water.
Tank 3.	... ...	0·56 inches "available" water.
Tank 4.	... ...	0·64 inches "available" water.

Furthermore, in Tank 2 with the sandy surface, the "available" moisture extends at least to a depth of 45 inches* while in the others the maximum depth of the "available" moisture is one foot. (See fig. 6.)

Thus the sandy surface has led to the accumulation of about 8 times as much "available" moisture as in the adjacent tanks even though all tanks were maintained under bare fallow conditions.

This experiment lends strong support to the field observations in showing the leaching effect of a low rainfall on a fallowed soil which has a sandy surface to promote water absorption, and to limit surface evaporation. It is also valuable in showing that the dominant movement of salt under these conditions is downward and that salt in the subsoil at a depth of several feet is unlikely to affect the surface in normal well drained soils of the Western Australian wheat belt.

SUMMARY AND CONCLUSIONS.

1. A review of the information in the literature concerning water movements in soil is made as a basis for the discussion of the movement of water soluble salts.

2. It is concluded that movement of moisture by capillarity is effective over short distances only.

3. In general capillarity would not be expected to raise water and, therefore, salts from a depth greater than 4 to 10 feet depending on the soil texture, and movement occurs rapidly only when the soil is quite moist—when it is at or above field capacity. A salt water table at less than 10 feet below the surface may thus allow the deposition of water soluble salts on the surface of the soil as a result of evaporation of water raised by capillarity.

4. In the light rainfall areas of Western Australia salt accumulation in the surface soils is observed—

(a) Where the salt water table is shallower than about 10 feet. The situation is very serious where the depth of the water is shallower than 5 feet.

(b) Where seepage occurs and evaporation of water leaves the residue of salt in the soil.

* An additional amount of 0·80 inches of "available" moisture was present in Tank 2 between the 45 inch level and 5 feet.

(c) On the rims of crab-holes where the micro-relief favours surface evaporation.

(d) Where special soil characters, in the absence of a shallow water table, lead to the establishment of capillary connection between a saline subsoil and the surface.

5. Diagrams have been constructed to illustrate the distribution of salt in soils where surface accumulation occurs in bare patches. The wick-like action involved in the upward and downward movement of salt is apparent. Soils of the morrel class, in which a powdery structure occurs, are most liable to surface accumulation of salt under these conditions. Similar accumulations occur on heavy-textured soils, but less commonly.

6. The effect of clearing on the movement of salt in saline soils under light rainfall conditions is discussed and it is shown that soil type is of paramount importance in determining the behaviour subsequent to clearing:—

(a) Sandy-surfaced soils with sandy-clay subsoils rapidly lose salt by leaching after the vegetation is cleared. From 10 to 15 tons of salt per acre may be removed from the upper three or four feet in the course of about two years after clearing.

(b) Medium-textured soils, for example, sandy loams, show substantial reduction in salt content or improvement in salt status following clearing.

(c) Heavy-textured soils and powdery soils of the morrel class show little reduction in salt concentration under ordinary farming conditions and are liable to surface accumulation of salt resulting in the appearance of sterile bare patches following clearing.

(d) Chlorides are leached most readily of all common ions in the water soluble salts and electrostatic balance is maintained by the formation of bicarbonates in the zone of leaching.

7. The results of a study of soils in tanks under a 13-inch annual rainfall support the field observations and show that under continuous fallow conditions—

(a) The main movement of water soluble salts in the profile is downwards.

(b) Where a saline layer is initially near the surface, sufficient upward movement may occur to be deleterious to crop growth.

(c) A sandy surface promotes moisture absorption and storage and hence greatly accelerates downward movement of salt.

8. A soil with a light-textured surface is most economical of moisture and is most suitable for agriculture under very low rainfall conditions.

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TRIALS WITH PASTURE AND FODDER SPECIES AND STRAINS AT DENMARK RESEARCH STATION.

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During the past season at the Denmark Agricultural Research Station a number of species and strains of pasture and fodder plants, which were obtained from various sources in Australia and overseas, were grown for the purpose of determining their growth, productiveness, and value, together with their immunity, if any, to attacks of the lucerne flea and red-legged earth mite.

Of the fodder plants, the most outstanding was the "Bell Windsor" variety of small seeded horse bean, the seed of which was obtained by Dr. T. Dunne originally from California and grown at the Muresk Agricultural College during 1936.

Last season approximately 1/15th of an acre of these beans was grown. They were sown during the second week of May in rows 3 feet apart. The seeding rate was 40 lbs. per acre, and superphosphate was applied at the rate of 2 cwts per acre.

Inter-cultivation to control weeds was carried out twice prior to the plants becoming too high for further cultivation.

In the earlier stages, the young plants suffered from the ravages of the lucerne flea and red-legged earth mite. The effects of these pests were noticeable on the leaves to a height of 15 inches until October.

Flowering commenced on the 21st August when the plants were 3 to 3½ feet high, and by the end of October the average height was 6 feet and flowering completed.

The plants averaged three stems with at least 50 pods per stem. When harvested it was estimated that the yield was over 60 bushels per acre.

Horse or tick beans thrive best on medium to heavy soils but will grow well on most well drained soils. The best method of sowing is in drills about 30 inches apart, the seeding rate between 40 to 60 lbs. per acre. Autumn and early winter is the best time for sowing. A simple method of seeding is to lightly plough in the seed every third or fourth furrow. It is necessary to give at least one inter-cultivation. These beans are such prolific yielders that they amply pay for any time and cultivation expended.

Tick beans are grown in this State principally for a green manuring or soiling crop in orchards, etc., but they can be grown for pig fodder or mixed with cereals for silage and may take the place of peas to some extent in the South-West, as they are not affected by the pea weevil.

At present all the seed sown is imported from the Eastern States.

Small experimental areas of these beans are being established in various centres in the South-West this season.

Of the other fodder plants grown, good results were obtained from the following:—

FIELD PEAS.—"Austrian Winter Pea" (*Pisum arvense*).

This is a white flowered variety which matures slightly earlier than the "Brunswick White" or "Dunn Field Peas." In the seedling stages it was noted that the "Austrian Winter Pea" was not as severely attacked by the red-legged earth mite and lucerne flea as other field peas. In the latter stages it was only slightly affected.

"The Austrian Winter Pea" is a vigorous grower and produces a heavy bulk of green material and is a prolific yielder of seed. It, however, was found that, like other peas of the genus "*Pisum*," it is severely damaged by the pea weevil. Further trials with this pea will be conducted this season.

VETCHES.—*Vicia spp.*

Of the seven species grown, three were outstanding:—

(a) *Grey Seeded Vetch.*

This is a late-flowering vetch. It was planted on 16th May but did not commence flowering until the first week of November. In the early stages the growth was prostrate, and the young plants were only slightly affected by the red-legged earth mite and lucerne flea. During the latter part of the season, this vetch produced a very heavy bulk of green material.

(b) *Vicia atropurpurea.*

This is also a late species with a more upright growth habit than the Grey Seeded Vetch, but produces a very heavy bulk of green material and was only slightly affected by the lucerne flea and red-legged earth mite.

(c) *Vicia sativa.*

Another late-flowering and maturing variety which was severely attacked by both the lucerne flea and red mite in the early stages of growth, but, when the growth became more rapid in the spring, little damage was done by these pests. This species was also a heavy producer of green material.

Of the others, *Vicia villosa*, the hairy vetch, was a failure, as it was practically completely destroyed by the red-legged earth mite in the seedling stage. *Vicia monantha*, an early-flowering and maturing species, was not attacked to any serious extent by the flea and mite, but it has a small leaf and is not a good producer of green material.

All the above mentioned vetches were immune to the attack of the pea weevil.

LATHYRUS SPP.

In this section three species were grown, these being the Tangier pea (*Lathyrus tangitanus*), *Lathyrus annus* and *Lathyrus sativus*. Examination of the seed produced showed that none of the *Lathyrus spp.* were affected by the pea weevil. The following gives the results obtained:—

(a) *Lathyrus annus.*

This species has a much finer type of stem and smaller leaves than the Tangier pea. In the earlier stages of growth, the young plants are attacked by both the red-legged earth mite and lucerne flea, but none of the plants were destroyed. Rapid growth does not commence until September and flowering begins early in November. This species is a very heavy yielder of seed and produces a good bulk of green material.

(b) *Lathyrus tangitanus.* Tangier Pea.

In the seedling stages this species was very severely attacked by red-legged earth mite and, to some extent, by lucerne flea. In a number of instances the young plants were completely destroyed. Those which survived produced a large bulk of green material, the stalks of which were rather coarse.

The Tangier pea is a prolific seed yielder, and one of the principal difficulties with it is the harvesting of the seed economically. Owing to the plants growing in a tangled mass, it is practically impossible to use machines of any kind to facilitate harvesting operations.

(c) *Lathyrus sativus.*

This is a much earlier species than either of the foregoing, as it is in full flower by the middle of October. It, however, is attacked by the red-legged earth mite and the lucerne flea but not as severely as the Tangier pea. The yield of green material and seed is good but not equal to that of the Tangier pea.

GRASSES.

During the past two seasons many additional species and strains of grasses have been grown to test their persistency, productiveness and suitability for non-irrigated conditions. The results to date are as follow:—

Rye Grasses (Lolium spp.).

(a) *Perennial.*

A total of 15 strains obtained during the previous two seasons from Victoria, New Zealand, Great Britain and locally were planted at the Research Station.

During the season 1936 the most outstanding strains were the Certified Victorian Clunes, New Zealand Hawke's Bay Certified Mother Strain, and St. Arnaud strain, which originated from the Clunes strain.

The recovery of all strains was observed after the first general rains early in March, 1937, following one of the driest summers on record for Denmark when the annual rainfall for 1936 was some 12 inches below the average.

The Clunes and St. Arnaud strains gave over 98 per cent. recovery, while other strains gave as low as 12 per cent. During 1937 these two were the most outstanding with the New Zealand Hawke's Bay and Victorian Colac next best.

Rusting of these grasses was severe in one case only. The majority of the strains were only slightly attacked, while the others were free.

All were only slightly attacked by the red-legged earth mite and lucerne flea, with the exception of five lines of Clunes.

(b) *Annual and Biennial Rye Grasses.*

Of the five under test the New Zealand Certified Italian rye grass was the most outstanding, producing an excellent bulk of green material and had a very high proportion of leaf to stem.

Phalaris tuberosa.

Of the seven lines under test, all showed signs of slight attack by the red-legged earth mite and lucerne flea. There was very little variation in the persistency and yield of the Victorian, New South Wales, and South Australian strains. All gave over 95 per cent. recovery after the first season.

Of the other grasses tested, the "Tall Fescue" was the most outstanding, giving very vigorous growth during the winter and spring, and the recovery was excellent in the autumn.

EXPERIMENTS WITH TOBACCO SEED-BED COVERS AT MANJIMUP (1937).

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The series of experiments initiated by the Department of Agriculture in 1936 with the object of discovering a satisfactory covering material for tobacco seed-beds, and an account of which was given in the issue of this Journal for December, 1936, pp. 503-507 (subsequently being reprinted as Leaflet No. 498), was continued during the 1937 season.

The following types of cover were tried:—

1. (Control). Unbleached calico treated with a mixture of paraffin wax, petroleum jelly, boiled linseed oil and mineral turpentine, as described in the above-mentioned article.
2. Unbleached calico, washed to remove the dressing and treated with boiled linseed oil.
3. Unbleached calico, washed to remove the dressing and treated with raw linseed oil.
4. "Windowlite," a flexible, translucent cellulose material, reinforced with fine mesh wire netting.

NATURE OF THE SEED-BEDS.

The small cold frames formerly used in the Department's seed-bed experiments were discarded in favour of long narrow beds of the usual commercial type. These were made 3 feet wide and 36 feet long, the jarrah frames being 15 inches high at the back and 6 inches high in front. Each bed was fitted with four sashes, each 9 feet long by 3 feet 3 inches wide, and hinged at the back so that the covers could be thrown open in fine weather and closed at night with a minimum of trouble. The covers were tacked on to these sashes, each of the four types of cover being fitted over one quarter of each bed. Three such beds were used in the experiment, thus permitting of each cover being replicated three times in order to lessen the chance of error due to inequality of soil or other cause.

The beds were sown on 4th August, and from then until germination they were watered every second day with slightly warmed water. It was observed that the surface of the soil under the windowlite covers tended to become drier than that under the calico covers.

Fig. 1.—General view of the 1937 Experimental Seed-beds at Manjimup. In the foreground are two tent-type beds. Behind them are the three beds fitted with experimental covers attached to hinged sashes. On the right are beds in which a number of varieties of tobacco seedlings was raised and fertiliser experiments carried out. The hinged covers on the bed on the extreme right bottom corner have been opened, and are being supported in a partially open position on wooden battens for photographic purposes.

—Photo by Author.

RELATIVE SPEED OF GROWTH OF SEEDLINGS.

The first signs of germination were observed under the windowlite and linseed oiled covers on 23rd August, 19 days after sowing, and under the "control" covers four days later. From then on, growth under all the covers was quite good, but the plants under the windowlite and calico treated with boiled and raw linseed oil came away rather more rapidly than those under the control (waxed) covers. The seedlings under windowlite especially made excellent progress, and were ready for transplanting at the beginning of October, just two months after the seed was sown. Growth under the two kinds of linseed oiled covers was about equal and only a very little behind that of the plants under windowlite, while growth under the control covers was definitely slower, the plants requiring about a week to ten days longer to reach transplanting size.

Benzol at a concentration of one square inch of evaporating surface to each square foot of seed-bed was introduced into all the beds about three weeks after germination, and no Downy Mildew appeared under any of the covers.

The seedlings were planted out in the Department's field experiment plots at Jardee, and no difference was observed between the seedlings grown under the various covers so far as percentage strike and subsequent growth were concerned.

LONGEVITY OF THE COVERS.

With regard to the covers themselves, the windowlite appeared to be in just as good condition at the end of the season as it was when new, and it would appear that this material, although expensive to instal, costing about 7s. 6d. per square yard, should last quite a number of years with reasonably careful handling, and cost no more in the long run than the less durable calico.

The calico covers treated with linseed oil, both raw and boiled, deteriorated badly, and were quite unfit for further use at the end of the season. It had been suggested to the writer that washing the dressing out of the new calico before

Fig. 2.—Seedlings in one of the experimental beds ready for transplanting.
—Photo by Author.

applying the linseed oil would obviate the rotting effect experienced in previous experiments, but this was not found to be the case.

The "control" covers treated with the paraffin wax mixture, while not producing quite such rapid growth of the seedlings, were in other respects quite satisfactory. They kept their appearance well, only a very slight amount of discolouration being evident at the end of the season, and the strength of the calico appeared to be practically unimpaired. These covers were stored away carefully at the end of the season and it is anticipated that they will be fit for use for another season at least.

HINGED SASHES ON SEED-BEDS HIGHLY DESIRABLE.

In addition to the three seed-beds used in this experiment, two beds of a rather simpler type were constructed and covered with waxed calico. These are shown in the foreground of fig. 1. In order to uncover these, the calico, which was tacked along the back of the bed, drawn over a slightly elevated centre rail, and fixed in

position by hooks along the front, had to be rolled up. As a rule it was still wet when rolled up in the morning, and it discoloured very badly as compared with similarly treated covers which were tacked to sashes. It is considered that the extra expense involved in fitting the seed-beds with removable or hinged sashes, to which the covering material is permanently attached, is justified by the saving of time

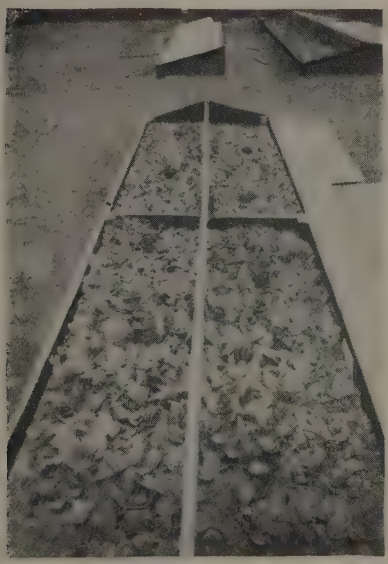

Fig. 3.—A tent-type seed-bed, showing raised centre rail and rolled-up cover alongside. The two rows of tins for holding benzol can be seen spaced at regular intervals along the bed.

—Photo by Author.

Fig. 4.—The reward of careful seed-bed management and careful attention to all the necessary techniques in the field subsequent thereto. The ripe leaf strung on the stick and about to be placed in the curing barn.

—Photo by Author.

occupied in covering and uncovering the beds and in the better preservation of the covers. As the time required for the benzol treatment of tobacco seed-beds each day, if the seed-beds are at all extensive, is already, in the aggregate, very considerable, the adoption of any time-saving devices, the cost of which is not prohibitive, is very well worth while.

DAIRY CATTLE IMPROVEMENT ACT AND AMENDMENT ACT.

The Department wishes to warn all owners of bulls who have failed to comply with the regulations under the above Act and take out registrations due for 1938, that action to enforce the provisions of the Act is now being taken. All farmers are therefore advised that it is essential for registrations to be finalised immediately.

THE NEW FRUITFLY REGULATIONS.

G. W. WICKENS,—
Superintendent of Horticulture.

The attention of all fruitgrowers throughout the State is drawn to the new fruitfly regulations given below, which were gazetted on the 20th May, 1938, in response to a request received by the Hon. Minister for Agriculture from the Fruitfly Advisory Board.

Two portions of the State, namely, those comprised in the Swan Road Board area and the Darling Road Board area, have been gazetted as infested places, and all owners or occupiers of orchards and/or vineyards in those areas must regularly, at stated periods, apply sodium fluosilicate bait to the trees and vines whether fruitfly is present or not.

The areas in the State outside those comprised in the road boards mentioned must apply sodium fluosilicate baits at stated periods commencing immediately fruitfly is discovered in the orchard and/or vineyard.

THE SCHEDULE.

The regulations made under and for the purposes of the Plant Diseases Act, 1914-1935, as published in the *Government Gazette* on the 16th day of September, 1921, are hereby amended by inserting therein after Division V. a new division, to stand as Division VA., as follows:—

Division VA.

Fruit Fly.

46A. The disease called Fruit Fly (*Ceratitis capitata*) shall be and is hereby declared to be a disease to which the provisions of section 8A of the Plant Diseases Act, 1914-1935, shall apply.

46B. For the purpose of controlling and eradicating the said disease and for preventing the spread thereof, the due observance of the provisions in this regulation hereinafter contained shall be appropriate steps and measures within the meaning and for the purposes of section 8A and section 8B of the said Act to be taken and adopted by owners and occupiers of orchards to which the said sections relate, that is to say:—

(A) In every orchard containing one or more fruit trees or one or more fruit vines, when either under section 8A or under section 8B of the said Act the owner or occupier of such orchard is required to take appropriate steps and measures for controlling and eradicating or for preventing the spread of the disease called Fruit Fly (*Ceratitis capitata*), such owner or occupier shall do or cause to be done the following things, namely:—

(i) gather all fallen fruit from the ground as follows:—

(a) Loquats, apricots, peaches, nectarines, plums, figs, pears, guavas, persimmons and quinces—once at least in every 24 hours.

(b) Apples, citrus fruits and other fruits not mentioned in the next preceding subparagraph—once at least in every three days;

(ii) destroy by boiling or by some other method approved by an inspector all fruit gathered from the ground as aforesaid and found to be infested with the said disease;

(iii) apply to every fruit tree and to every fruit vine in the orchard having fruit thereon by means of a hand syringe or a spray pump, or by some other method approved by an inspector, fruit fly bait made in accordance with the formula hereinafter prescribed or in accordance with some other formula as hereinafter mentioned and provided for, and which shall be so applied according to the following directions, namely:—

(a) at least one gallon of the fruit fly bait shall be used to every forty fruit trees or to every one hundred fruit vines required to be treated, and so that each fruit tree or each fruit vine is thoroughly sprayed or treated;

(b) the first application of the fruit fly bait shall be made when the fruits on the trees or on the vines (as the case may be) are within six weeks of ripening;

(c) after such first application aforesaid further applications shall be made at least once in every six days during the whole of the ripening period; and until the expiration of two weeks after all the ripe fruits shall have been removed or fallen from the said fruit trees or the said fruit vines.

(B) The formula for making fruit fly bait as provided for in and for the purposes of paragraph (A) of this regulation shall be as follows:—

Sodium fluosilicate	1 ounce.
Sugar	2½ lbs.
Water	4 gallons.

Provided that, in lieu of the said formula, any other formula may be used of which the Minister approves as notified in the *Government Gazette* whilst such notification remains unrevoked by a subsequent notification in the *Government Gazette*.

Plant Diseases Act, 1914-1935.

Department of Agriculture,
Perth, 12th May, 1938.

I, THE undersigned, Minister for Agriculture, being the Minister charged with the administration of the Plant Diseases Act, 1914-1935, acting in exercise of the power in this behalf conferred upon me by section 8B of the said Act and for the purposes of subsection (2) thereof do hereby declare that those portions of the State which are comprised within the boundaries of the Swan Road District and the Darling Range Road District as now constituted under the provisions of the Road Districts Act, 1919-1934, respectively, are each and both of them infested with the disease called Fruit Fly (*Ceratitis capitata*) which is a disease to which sections 8A and section 8B of the said Act, and the regulations made under the said Act, apply.

(Sgd.) F. J. S. WISE,
Minister for Agriculture.

Approved by His Excellency the Lieutenant-Governor in Executive Council this 12th day of May, 1938.

(Sgd.) L. E. SHAPCOTT,
Clerk of the Council.

THE TUNG-OIL TREE.

(*Aleurites Fordii* Hemsl.)

G. R. W. MEADLY,
Acting Government Botanist.

Much has been said and written in this State recently concerning the Tung-oil tree, and this short article has been prepared following inquiries from many sources.

The Chinese wood-oil or Tung-oil tree, native to Central and Western China, is now cultivated commercially in other countries, especially the United States of America. It is a deciduous tree which attains a height of 25 feet and produces a fruit two to three inches in diameter, somewhat like a small orange in shape. Each fruit contains three to seven firm, brown-coated seeds from which the oil is extracted. In China this oil has many incidental uses, such as for lamp oil and medicinal purposes. Its main commercial uses, however, are in the manufacture of waterproof varnishes, paints, etc., rubber substitutes, linoleum and insulating compounds. The United States imports about 13,000,000 gallons annually, whilst the consumption in Australia, although at present only about 150,000 gallons, is steadily increasing.

As the Chinese apparently have not attempted to cope with the increased demand by preparing extensive plantations to supplement the natural supply, other countries are investigating the possibility of producing their own requirements.

In 1931 one thousand seeds of the Tung-oil tree were obtained from the Royal Botanic Gardens, Kew, for trial purposes. These were distributed to various parts

Tree, four years old, growing at Byford.
[*Photo by courtesy of the "Sunday Times" newspaper.*]

of the State including Hamel, Bridgetown, Salmon Gums, Beneubbin, Broome and Perth. A fair germination was secured at Broome, but the young plants were dried considerably by the hot winds. The Forests Nursery at Hamel raised 126

plants, but apart from this no encouraging reports were received. These plants were distributed to various places in the South-West, but the results secured cannot be considered satisfactory. Many failures, however, were certainly due to lack of attention. A number of trees raised from seed planted four years ago at Byford are now bearing and provide the most encouraging results achieved with the Tung-oil tree in this State.

Three trees which were not transplanted from the original nursery site are now approximately twenty feet high. Last year they yielded a few pounds of seed each, and this season, although the crop has not yet been gathered entirely, they are expected to average about 10 pounds of fruit per tree. The trees which were transplanted are not so far advanced and, in the main, have not received the attention given to the three larger trees.

Most of the Tung-oil trees growing in this State were planted in August of last year on a variety of soils. A number of failures have been tempered by some quite encouraging results, but all the orchards are young and still essentially in

Fruiting branch on the tree illustrated.
[*Photo by courtesy of the "Sunday Times" newspaper.*]

the experimental stage. Until they are four or more years old, when some idea of the yield of fruits may be ascertained, no decision of very significant value can be made concerning the future of the industry in this State. A condition evident in all orchards visited is a lack of uniformity in growth. Some trees after nearly twelve months are over two feet in height, while others have produced shoots only a few inches long on the original stocks. In some cases the cause is obviously poor drainage, but in others the reason is not so evident and frequently appears to depend upon the condition of the individual trees when planted. Healthy trees were noted on different soil types, including sand containing very little loam, a rich loam and a very gravelly loam. In no cases where poor drainage was evident were satisfactory results secured, and some orchards were irrigated during the summer months. Available summer moisture will probably constitute the limiting factor associated with Tung-oil production in this State.

As local experience does not allow us to advise regarding cultural methods, etc., the following information has been compiled mainly from Bulletin No. 12 (3rd edition) prepared by A. R. Penfold and F. R. Morrison and issued by the Technological Museum, Sydney.

PLANTING.

The seeds germinate in Australia about late September and October, and therefore the correct time to sow the seed is in the early spring. Improved results have been secured by soaking the seeds for a period of 36-48 hours prior to planting. The best practice is to purchase seed only in the husk and to dehusk just prior to soaking in water.

THE NURSERY.

The nursery site should be a sunny, well-drained portion of the garden or plantation area, and the ground worked into a fine tilth. Sowing in rows three feet apart is recommended, spacing the seeds about eight inches and covering with about 1½ inches of soil. Germination usually occurs between thirty and sixty days after sowing according to locality and prevailing climatic conditions, but some seed has germinated after remaining in the ground for more than twelve months.

Care should be taken when the seedling first emerges from the seed-case to maintain the soil around the young plant in a loose and friable condition. The application of a well-balanced fertiliser, especially well-rotted manure, will hasten the growth of the young plants. After about nine months, in the dormant season when the leaves have been shed, the plants should be ready for lifting and setting out. As the plants at this stage are normally 12-18 inches in height and have a root system about twelve inches long, care must be taken to retain as much of the root soil as possible and thus avoid destruction of the feeding root hairs.

THE ORCHARD.

The planting of seeds in the actual position where the trees are to remain is recommended, although many growers prefer to use the plants grown in the nursery. Practically any soil, provided it is well drained and contains sufficient available moisture in the summer, is suitable, but the ideal appears to be a slightly acid sandy loam or loam underlaid with clay at a depth of 3-5 feet. The plantation area should be ploughed and cultivated to a fine tilth.

As a general rule Tung trees can be expected to grow in areas where citrus culture is conducted successfully, but regions subject to erratic and unseasonable frosts and low rainfall should be avoided.

Australian experience has led to the conclusion that an initial planting of 160-200 trees per acre is desirable. This number permits the weeding out of weak plants during the first three or four years without disturbing or checking the growth of the remaining trees. For profitable results fully 150 vigorous trees, well formed and good bearers of fruit, are necessary by the fifth or sixth year.

The plantation should be cultivated to maintain a clean floor, which is best done by shallow discing during the growing period. Freedom from all rubbish immediately around the trees is most desirable, as borer trouble may develop if the quick growing tree is wounded by the action of hoes or other appliances. In accordance with American experience, it is recommended that the orchardist makes full use of the alleys between the trees for the production of suitable annual crops for green-manure purposes.

Fertilisers should be chiefly nitrogenous, farmyard manure being preferable, and care should be taken when applying artificial manures. If the site of the

orchard is virgin land, the problem of artificial manures will not be a pressing one until the trees commence to bear. Applications of a few ounces to one pound of a complete fertiliser adjacent to each tree will then hasten growth and increase the leaf surface.

The tree is a fast grower, normally producing some fruits when three years old. A good crop of fruit yielding oil of satisfactory quality, however, is not secured before the fourth or sometimes the fifth year.

The grazing of stock in Tung orchards is not advised owing to the danger of limbs being broken by cattle rubbing against them. Animals can do appreciable damage in this manner, and goats have also shown a predilection for the foliage of the trees.

Young tree seven months old after transplanting from the nursery.
[*Photo by courtesy of the "West Australian" newspaper.*]

DISEASES AND INSECT PESTS.

The Tung-oil tree is relatively immune from attack by disease and insect pests, only a few instances of minor importance having been recorded in Australia. As the cultivation of this tree extends, however, more difficulties of this nature must be anticipated.

YIELD.

Naturally the yield of fruit is very variable, but Penfold and Morrison consider that a tree to be of commercial value for oil purposes should yield a minimum of 1,000 fruits per annum. To predict the yield of oil likely to be obtained under local conditions is extremely difficult, but a conservative estimate upon which to base the probable return from a fair average commercial grove is about half a gallon of oil per tree from the sixth to the tenth year.

ALL AUSTRALIAN PORKER AND BACONER CARCASES COMPETITION.

G. K. BARON-HAY,
Superintendent of Dairying.

During 1937 the Australian Meat Board organised competitions for classes of porker and baconer carcases suitable for export, with the view of encouraging the breeding and management of pigs so as to produce a type of carcase suitable for the English market.

The results from the first competition are now to hand, the judging having been carried out by Mr. H. R. Davidson of the School of Agriculture, Cambridge, and Mr. Jos. B. Swain of Empire Pork House, London.

The judging was carried out in accordance with the standards laid down by the above two judges and Dr. John Hammond of the School of Agriculture, Cambridge, so as to comply with the requirements of the British bacon and pork market.

Baconer Carcases Competition.

Thirteen entries in this class were received from the various States, one only being from Western Australia, which was submitted by Mr. W. G. Burges, Burges' Siding.

Table 1 shows the total marks which were awarded to each of the entries in this class.

TABLE 1.

ALL AUSTRALIAN BACONER CARCASE COMPETITION—SMITHFIELD, LONDON. DECEMBER, 1937.
Analysis of Results for Individuals on a Percentage Basis.

—	Individual Competitors Results.	Principal Feeds, etc.	Breeds.	Marks Awarded.	Percentage.
					%
South Australia	Inspector General of Hospitals (entry No. 6)	Crushed barley, crushed wheat, crushed peas, skim milk	Large White	280	74·6
Victoria	W. Logie (entry No. 2)	Barley and boiled potatoes	Large White x Large White x Middle White	269	71·7
Queensland	Kingston Farm Pig Co. (entry No. 2)	Buttermilk, maize, pollard, oatmeal. Paddock reared; finished last 6 weeks in pens	Large White	261	69·6
South Australia	J. W. Aldridge (entry No 2)	Peas, barley and meat meal	Large White	258	68·8
South Australia	Inspector General of Hospitals (entry No. 5)	Crushed barley, crushed wheat, crushed peas, skim milk	Large White x Berkshire	257	68·5
South Australia	W. H. E. Crosby (entry No. 3)	Mixed corn, skim milk, pollard; free range	Large White x Tamworth x Berkshire	250	66·6
Victoria	H. C. Nankivell (entry No. 1)	Pasture skim milk, boiled potatoes, finished with barley, peas and skim milk	Large White	249	66·4
Victoria	F. Hawtin (entry No. 1)	Milk, pollard, crushed barley; yard feed	Large White	246	65·6
South Australia	J. W. Aldridge (entry No. 4)	Peas, barley and meat meal	Large White x Berkshire	246	65·6
Victoria	Nestle Anglo Swiss Milk Co. (entry No. 1)	Buttermilk, whey and crushed barley; indoors from time of birth	Tamworth x Berkshire	240	64·0
South Australia	J. H. Dawkins (entry No. 1)	Crushed barley and meat meal	Large White x Middle White x Large White	225	60·0
Western Australia	W. G. Burges (entry No. 1)	Wheat, Meat, Meal	Canadian Berkshire	218	58·1
Queensland	Kingston Farm Pig Co. (entry No. 1) (Not in competition—2 carcases only)	Buttermilk, maize, pollard, oatmeal; paddock reared; finished last 6 weeks in pen	Large White	172	68·8

The winning exhibit submitted by the Inspector General of Hospitals in South Austra ia is shown in Illustration 1, the detailed points for which are as follow. (See Table 2.)

Illustration 1.—Winning baconer entry, exhibited by Inspector General of Hospitals, South Australia.

TABLE 2.

AUSTRALIAN MEAT BOARD PIG COMPETITION, DECEMBER, 1937.
Judges: H. R. DAVIDSON and JOS. B. SWAIN.

Winning Exhibit Baconer Class.

Breed—Large White. Inspector General of Hospitals. Entry No. 6.

	Maximum Marks.	Actual.	Marks.	Ideal.	Actual.	Marks.	Ideal.	Actual.	Marks.	Ideal.	Percentage.
A.—Inspection											
Skin .... }	5	....	5	....	....	5	....	....	5	....	100
Colour .... }											
Dressing	5	....	5	....	....	5	....	....	5	....	100
Hams	8	....	5	....	....	4	....	....	6	....	62·5
Shoulders	7	....	4	....	....	5	....	....	4	....	61·9
Streak	12	....	7	....	....	7	....	....	7	....	58·3
B.—By Measurement											
Eye Muscle	28	46	20	54	44	19	53	47	21	54	71·4
Fat Thickness	20	22	18	20	16	17	19	17	17	20	86·6
Body Length	20	745	8	865	770	15	795	780	13	815	60
Leg Length	5	580	2	559	585	1	554	560	5	564	53·3
Wgt. Suitability	15	....	15	....	....	15	....	....	15	....	100
Total	....	....	89	....	....	93	....	....	98		...
Total (3 carcases)	....	....	....	....	....	280	....	....	....	....	74·6

In commenting on the exhibits in the baconer class, the judges stated that the carcases which were submitted for the competition were generally superior to the commercial product, which has not always been the case in other competitions and indicates the great interest, care and attention given by competitors in the preparation of their pigs.

The importance of having 3 carcases in each entry is corroborated by several exhibits. Not only does this give a better average for marking purposes, but reduces the inevitable risk when pigs which are to be judged on carcase points only must be selected alive.

In one exhibit from South Australia where the carcase weighed 160 lbs., it was undoubtedly the leanest looking carcase of the three in that entry when judged on external conformation but proved to be the fattest when cut through the loin. This relationship has been noticed by the judges on other occasions and proves not only the importance of carcase tests in addition to live weight inspection but also the necessity of having a fair sample to judge.

While the results have been analysed on a breed basis, the judges feel that too much attention should not be placed on this, owing to the small numbers of pigs which have been inspected. A standard product is what is required by the Smithfield Market, and, as there are of necessity considerable variations in management and environment, it may be necessary to use different types within the breed to arrive at the standard carcase. This is in accord with Departmental advice which has been to restrict the number of breeds as far as possible and to rely on selection within the breed for improving the standard of carcase.

The following comments on the different points which have been judged are of interest:—

Skin and Colour.—5 marks.

It is necessary for successful marketing that the carcase should retain its natural bloom and be free of bruise marks, scratches, bites, etc. Even in this com-

petition where it would be expected that pigs had been treated with special care, entries were submitted which were bruise marked and blotchy in appearance.

Dressing.—5 marks.

All entries scored 100 per cent. of marks so that this point calls for no comment. This should be gratifying to exhibitors and indicates that, provided the right type of carcase is submitted to the abattoirs, the treatment there can be carried out in a satisfactory manner.

Hams.—8 marks.

The average marks for all entries was 72.3 per cent. of the possible total and indicates that the hams were very good.

The variation in the breed analysis was from 62.5 per cent. to 87.5 per cent. and follows breed characteristics fairly closely.

It will be noted in Table 3 that pigs containing "Berkshire" blood have scored highly for hams, while the "Large White" crosses were generally weak in type of ham. In each case, however, these breeds have other compensating factors.

Shoulders.—7 marks.

With an average of 68 per cent. marks, the type of shoulders was not quite so good as the hams. The exhibit of Canadian Berkshires from Western Australia was surprisingly low in points for this section. Generally, it is to be expected that, where hams are good, shoulders will not be quite so good, and *vice versa*

In the illustration of this, it will be seen that the "Large White" breed has the lowest marks for hams and the highest for shoulders, and that the Canadian Berkshire exhibit has the highest marks for hams and the lowest for shoulders. This is an indication that in every breed careful selection is necessary in order to develop a high quality standard carcase.

Streaks.—12 marks.

This point should be regarded as very good and potentially better than is shown by the average score of 60 per cent. marks.

Points were lost mostly because the "streak" was not thick enough rather than that there was an insufficient amount of lean through the meat. Had there been a little more fat between the muscles, many of the "streaks" would have earned full marks.

Eye Muscle of Loin.—28 marks.

The standard set for this point is a severe one, as it is most important to encourage its development. The average marks of 59.3 per cent should accordingly be considered a good result.

The average of the "Large White" exhibits was comparatively good, although in other entries individual carcases scored well, the average being reduced by other lower scores. This again stresses the importance of selection for type within the breed.

Back Fat Thickness.—20 marks.

The results under this heading are very good and even better than suggested by the average of 66.1 per cent. of possible marks.

It is interesting to note that an exhibit by Mr. W. Logie of Victoria, whose exhibit was second in the competition, scored 96.6 per cent. for thickness of back

fat, which the judges remarked was the best score that has yet been recorded under this system from any pen of three pigs.

The entries, generally, lost marks through too great a thickness of back fat.

Body Length.—20 marks.

It is in respect of this point, on which the average marks of all entries only reach 45.6 per cent. of the possible, that the entries as a whole are deficient. There is, however, great variation, the difference between the best and the worst being 59.7 per cent.

Even within one breed—the "Large White"—there is a variation of from 48.3 per cent. to 75 per cent., while in this particular section the exhibit of Canadian Berkshires only scored 13.3 per cent. of the marks for body length—a character in which this breed usually excels.

Leg Length.—5 marks.

The average marks of 72.6 per cent. are very good indeed, particularly considering the preponderance of "Large White" influence which generally scores low in this section.

"Berkshire" and "Middle White" entries were particularly good in this section, especially the "Berkshire."

Suitability of Carcase Weight.—15 marks.

Loss of marks in this section is entirely under the control of exhibitors, as the optimum marks for the most suitable bacon market weights, namely, 135 to 154 lbs., should be well known.

TABLE 3.

Analysis of Breeds.

	Maximum Marks.	Large White.	Large White x Berkshire.	Large White x (Tamworth x Berkshire).	Large White x (Middle White x Large White).	Tamworth x Berkshire.	Canadian Berkshire x Berkshire.
		6 entries.	2 entries.	1 entry.	2 entries.	1 entry.	1 entry.
A.—By Inspection		%	%	%	%	%	%
Hams	8	66·1	68·7	87·5	77·0	79·1	81·6
Shoulders	7	72·2	69·0	66·6	69·0	61·9	47·6
Streaks	12	66·6	51·8	50·0	48·5	72·2	61·1
B.—By Measurement							
Eye muscle of loin	28	60·9	61·9	51·1	64·9	51·7	51·1
Back fat thickness	20	63·5	63·3	65·0	76·6	66·6	66·6
Body length	20	62·0	50·8	46·6	20·0	26·6	13·3
Leg length	5	56·4	83·3	100·0	80·0	73·3	100·0
Average	100	63·2	60·8	59·3	58·3	56·0	52·6

Porker Carcases Competition.

In the porker carcases competition nine entries were received, no entries being forwarded from Western Australia.

The winning exhibit was forwarded by A. H. Callaghan, Principal, Roseworthy Agricultural College, a reproduction of which is shown in Illustration 2, and the detailed marks for which are shown in Table 4.

Illustration 2.—Winning porker entry, exhibited by A. H. Callaghan, Principal Roseworthy Agricultural College, South Australia.

TABLE 4.

AUSTRALIAN MEAT BOARD PIG COMPETITION, DECEMBER, 1937.
Judges: H. R. DAVIDSON and JOS. B. SWAIN.

Winning Exhibit Porker Class.

Breed—Can. Berk. x Large White. A. H. Callaghan. Entry No. 3.

	Maximum Marks.	Actual.	Marks.	Ideal.	Actual.	Marks.	Ideal.	Actual.	Marks.	Ideal.	Percentage.
A.—Inspection											
Skin	5	....	4	....	....	4	....	....	4	....	80
Colour	5	....	4	....	....	4	....	....	4	....	80
Dressing	5	....	5	....	....	5	....	....	5	....	100
Hams	8	....	6	....	....	5	....	....	5	....	66·6
Shoulders	7	....	5	....	....	5	....	....	5	....	71·4
Streak	12	....	9	....	....	9	....	....	6	....	66·6
B.—By Measurement											
Eye Muscle	28	42	20	50	42	21	50	43	21	50	73·8
Fat Thickness	20	14	18	12	13	19	11	15	16	12	88·3
Body Length	20	655	10	705	662	13	695	660	11	705	56·6
Leg Length	5	485	4	479	485	3	469	475	5	479	80
Total	....	....	85	....	....	88	....	....	82	....	.
Total (3 carcases)	....	....	....	....	....	255	....	....	....	....	73·9

It is interesting to note that the Inspector General of Hospitals in South Australia forwarded the exhibit gaining second place in the porker class and whose exhibit in the baconer class occupied the winning position.

In connection with this competition, the judges report that this was carried out in accordance with the standard laid down as for baconer classes, and includes marks for skin, colour and dressing.

Skin and Colour.

The results of 89.5 per cent. and 87.6 per cent. respectively are very good, losses being accounted for by slight bruises, scratches, and bites.

Owing to inclement weather, photographs had to be taken by flashlight, which may give misleading results owing to shadow.

Dressing.

All States scored 100 per cent. except New South Wales where one mark from each carcase was deducted because the fore feet were incorrectly tied up, which tends to throw the shoulders out of shape and may cause low marks for shoulders.

Hams, with a result of 67.8 per cent., were quite up to standard and would have been better but for the poor result of 50 per cent. in one State.

Shoulders showed a considerable variation, the average of 62.3 per cent. being quite good, but one State with only 38 per cent. was well below normal.

Streaks.

An average marking of 59.1 per cent. is possibly better than it appears, as there was not sufficient fat between the meat. Apparently competitors endeavoured to obtain too lean a carcase with a loss of marbling fat.

Eye Muscle of Loin.

The result of 65.9 per cent. is good, although there is very wide difference in many of the carcases.

Back Fat.

The average marks of 74 per cent., which would have been better but for the low marks in one State, are very good and indicate that the Australian farmer realises that the British public requires lean meat.

Body Length.

Body length as in the case of the baconer exhibits was not good, although the average of 50 per cent. is reduced by the Queensland entries which gained only 31.6 per cent. It is interesting to note that these entries were of crossbred "Middle Whites."

Leg Length.

Leg length with an average of 61.9 per cent. was good and was reduced by the Victorian entry with only 40 per cent.

General Remarks.

The pigs were of good marketable quality, and a study of the individual reports and the analyses perhaps will give the clearest indication of the results which at 66.9 per cent. for the whole competition are good.

Owing to the wide variation of breeds and crossbreds, a detailed analyses of the results would be unjustified. It is felt, however, that the consistently low marks for "body length" where the "Middle White" is used in crossing cannot be ignored.

Tables Nos. 5 and 6 below give details of the exhibits from each State and the average marks obtained in each section.

TABLE 5.

ALL AUSTRALIAN PORKER CARCASE COMPETITION -SMITHFIELD, LONDON, DECEMBER, 1937.

Analysis of Results of Individual competitors.

Competitors Results.	Principal Feeds and Husbandry.	Breeds.	Marks Awarded.	Percentage.
South Australia— A. Callaghan (entry No. 3)	Mixture of barley, wheat and peas ; mainly outside feeding	Canadian Berkshire x Large White	255	73·9
South Australia— Inspector General of Hospitals (entry No. 4)	Crushed barley, crushed wheat, crushed peas, skim milk	Large White x Berkshire	244	70·7
New South Wales— Australian Chilling & Freezing Co. (entry No. 1)	Wheat, butter-milk, lime-water, offal and greenfeed	Large White x Tamworth	227	65·7
South Australia— E. A. Farr (entry No. 5)	Skim milk and crushed barley	Large White x Large White x Berkshire	225	65·2
Victoria— W. Logie (entry No. 1)	Barley and boiled potatoes	Large White x Large White x Middle White	210	60·8
Queensland— Wallace & Son (entry No. 1) (1 pig only 80 lbs.)	Kitchen refuse with meat meal and maize meal	Tamworth x Middle White	81	70·4
Wallace & Son (entry No. 2) (1 pig only 72 lbs.)	Kitchen refuse with meat meal and maize meal	Middle White x Tamworth	79	68·6
G. W. Winch (entry No. 3) (2 pigs 64 and 66 lbs.)	Table scraps, red comb, pig meal, Borthwicks mebo, no milk : housing intensive system	Middle White x Berkshire	137	59·5
G. W. Winch (entry No. 4) (2 pigs 79 and 85 lbs.)	Table scraps, red comb, pig meal : no milk	Middle White x Tamworth	160	69·5

TABLE 6.

ALL AUSTRALIAN PORKER CARCASE COMPETITION—SMITHFIELD, LONDON, DECEMBER, 1937.

Report and Analysis of Results of States.

	Maximum Marks.	New South Wales.	Victoria.	Queensland.	South Australia.	Average for All States.
		%	%	%	%	%
A.—By Inspection						
Skin	5	93·3	100	86·6	86·6	89·5
Colour	5	100	86·6	86·6	84·4	87·6
Dressing	5	80	100	100	100	97·1
Hams	8	62·5	50	77	69·4	67·8
Shoulders	7	38	80·9	61·9	66·6	63·2
Streaks	12	61·1	52·7	61·1	59·2	59·1
B.—By Measurement						
Eye muscle of loin	28	61·9	58·3	72·6	65·4	65·9
Back fat thickness	20	80	56·6	72·5	78·8	74
Body length	20	51·6	50	31·6	61·6	50
Leg length	5	66·6	40	70	62·2	61·9
Total	115					
Total all in average for each State		65·5	60·8	66·2	69·9	
Total all in average all States	....	....	....	....	....	66·9

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